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An assessment of biological processes close to the sea-bed in a slope region and its significance to the assessment of sea-bed disposal of radioactive waste.

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ABSTRACT

Vertical profiles of planktonic and micronektonic biomass observed close to the sea-bed along a transect running up the continental slope on the southern flank of the Porcupine Seabight (to the southwest of Ireland) showed that a doubling in biomass concentration occurs from 100 to 10m above the sea-bed. Comparison with biomass concentrations at two deep water stations, one in the Seabight and the other in the Rockall Trough, showed that there was a consistent increase in standing crop close to the sea-bed over the slope. Supplementary data were collected on the northern flank of the Seabight. Analysis of both taxonomic groups and individual species showed that some taxa were more abundant near the sea floor and extended their vertical ranges to greater depths over the slope than over deep water, other taxa were unaffected.

The implications to the problem of assessing the safety of sea-bed disposal of high level radioactive waste are:- 1. Biological activity increases close to the sea-bed; 2. Slope regions are areas where the potential for vertical transport of material by biological processes is enhanced; 3. There may be dynamic links across slopes between deep-living communities and the shelf communities which are heavily exploited for living resources; 4. Hence any isotopes which might be transported by physical processes from a dumpsite and impinge on the slope may become incorporated into a highly dynamic system, but it is unclear as to whether the dominant flux would be up slope or back onto and into the sediment.

INTRODUCTION

The examination of whether it is feasible to safely dispose of high level radioactive waste in the oceans involves basically two questions. Firstly, does the dumping create an unacceptable risk of substantially damaging marine ecosystems and secondly will the dumping result in the risk of an unacceptable dose of isotopes either to individual critical groups of Man or to the population as a whole. Both these questions are essentially of a biological nature and if they are to be answered with precision a much more extensive understanding of marine ecosystems needs to be developed. However, by careful and thorough exploration of critical elements of the ecosystem - these are the 'bottlenecks' that essentially control the rates at which the whole system functions - it is possible to determine maximum limits to the risks. The acceptability of these limits will then be subject not to scientific judgements but to value judgements which will be based upon considerations such as financial costs, the environmental risks associated with energy sources, availability of resources for energy generation and the forecasts of global energy needs. However, a well-founded scientific evaluation is a prerequisite for these value judgements to be made sensibly.

The first biological communities to encounter any isotopes released into the water from canisters of disposed waste will be the benthic organisms. Dispersal of the isotopes may then occur either via biological pathways or through physical transport processes of currents, diffusion and mixing. Simple models have been developed (Robinson and Mullin, 1981; Needler, in press) which suggest that at abyssal depths dispersal by physical mechanisms is likely to be several orders of magnitude greater than by biological processes. This can also be simply checked by assuming that all the organic material that reaches the sea-bed is converted into benthic production which is returned back to the surface. However, even by applying the highest concentration factors known, this hypothetical mechanism will transport several orders of magnitude less isotope back to the surface than the best estimates for physical processes. Thus the organic input into the deep sea sets the limit to what can be returned back to the surface. Angel (1983) has reviewed all the known mechanisms of vertical movement by organisms and concluded that any such transportation is relatively trivial, and that no critical fast pathways have yet been identified. Similarly physical transportation vertically is extremely slow compared with transport laterally by currents, eddies and diffusion. Lateral transport may occur either with the isotopes in solution, or bound onto suspended particulates or in the bodies of organisms inhabiting the benthopelagic environment. This lateral transport may either result in the movement of isotopes along density surfaces which outcrop at the surface at high latitudes or may result in their impingement on the continental slope. Although in all probability most of the isotopes will be progressively dispersed and diluted along the lateral transport pathways and will also be subject to removal back onto the sea-bed by the chemical scavenging of the rain of sedimentary particulates, it is just conceivable that enough isotope to cause a measure of concern could arrive in the vicinity of a continental slope. Observations on the dispersion of isotopes after the Thule accident (Aarkrog, 1979) and at the Fallaron Islands dump site show that this lateral dispersion is still very slow (Dyer, 1976).

Wishner (1980) demonstrated that the standing crop of plankton increases quite sharply within about 100m of the sea-bed at abyssal depths. Angel and Baker (1982) were able to provide further confirmation of this phenomenon off N.W. Africa. This increase leads to a doubling of the concentration of biomass in the overlying water at about 10m above the sea-bed and further enrichment may occur even closer to the bottom. These populations are probably dependent on the rain of detritus from the surface layers which appears to amount to 1-3% of primary production in tropical and subtropical seas (see Angel 1983 for review), but at high latitudes sedimentation of blooms may result in higher but more seasonally-pulsed fluxes of organic matter to the sea-bed (Billett et al., 1983). The prime source of food will probably be at the sediment/water interface. However, predation pressure will probably be more intense at the sea floor and so organisms may use the overlying water as a refuge. Therefore biological processes will be more dynamic in close proximity to the sea-bed, and there may be an active interface between the deep sea systems and the shelf ecosystem up the continental slope.

This study was aimed at having a first look at this interface in order to try to gain a feel for whether it will behave as a bottleneck to the movement of isotopes up the slope or whether there is a high probability that any isotopes reaching the slope will move quickly up into the neritic realm, into much closer contact with Man's activities.

In the Biology Department at IOS, a programme has been carried out over the last decade to examine the way in which the vertical profiles of plankton and micronekton vary with locality throughout the Northeast Atlantic. Consequently a considerable volume of background information has been accumulated in the context of which it is possible to interpret any variations that may occur in the patterns of vertical distribution. The area chosen for a Discovery cruise, to examine and describe processes over the slope, was the Goban Spur which lies on the southern flank of the Porcupine Seabight. In this region the slope is relatively smooth and is relatively gently sloping. The benthic group in the IOS Biology Department had already conducted a number of cruises to the Seabight, including a Challenger cruise when some preliminary near sea-bed sampling had been carried out. Two deep water stations were studied during the same Discovery cruise, one well to the north in the Rockall Trough, the other just off-slope in the mouth of the Seabight. These two deep water stations have been used to provide comparable deep water profiles against which it has been possible to assess the changes in the profiles over the slope.

The report is divided into two main sections. The first which is the most extensive describes the main block of data from Discovery Cruise 105. A smaller second section includes the results from the preliminary sampling carried out on the earlier Challenger cruise which, are less conclusive but did extend the observations to the north flank of the Seabight and into both deeper and shallower water.

SECTION 1

RRS DISCOVERY CRUISE 105, 1979

1. a. MATERIALS AND METHODS

Four stations (10108-10111) were worked in August/September 1979 on the Goban Spur on the southern flank of the Porcupine Seabight over soundings ranging from 900-1700m. Two deep water stations were also worked, one in the Rockall Trough (Station 10105) centred at 54°30'N, 13°W (sounding ~ 3000m) and another in the Porcupine Seabight (Station 10115) centred at 49°40'N, 14°06'W (sounding ~ 4000m) (Fig. 1).

At all of these stations samples were collected using a multiple Rectangular Midwater Trawl (RMT 1+8M), (Roe and Shale, 1979; Roe *et al.*, 1980). The mean mouth area of these nets varies with the towing speed but at a speed of two knots the mouth area of the RMT 8M is 8.4 square metres and of the RMT 1M is 0.7 square metres. The mesh sizes of the RMT 8M is 4.5mm and of the RMT 1M is 0.32mm. This opening/closing net system consecutively collects three pairs of plankton (in the RMT 1M) and micronekton (in the RMT 8M) samples. The nets are operated acoustically, and data on depth of fishing, *in situ* water temperature, speed of net through the water and depth at which net is fishing are all telemetered back to the ship. For each haul, the mean towing speed was used to calculate the average mouth angle using the formulae given by Roe *et al.*, (1980). The volume of water was then estimated from the total distance run. During a one hour tow at two knots the RMT 8M filters approximately 28,000 cubic metres of water and the RMT 1M filters approximately 2,500 cubic metres of water.

At each slope station a series of horizontal tows were made within relatively narrow depth strata measured relative to height above the sea floor rather than absolute depth. The majority of hauls were collected within 100m of the bottom and several hauls were collected within 20m of the bottom (Fig. 2). Nets were towed parallel to the general line of the shelf break so that the change in sounding during the course of the tow was minimised. However, inevitably there were changes in soundings between different hauls at any one station; this was particularly noticeable at Station 10111. Initially a near-bottom indicator streamed from the net weight bar was used to indicate the height of the net above the sea floor (Boxshall and Roe, 1980). However, although an electrical fault prevented the indicator functioning effectively the calm conditions made it possible to pick up the weak bottom echoes of the acoustic signals transmitted by the net monitor reflected by the sea floor. These reflections were used to

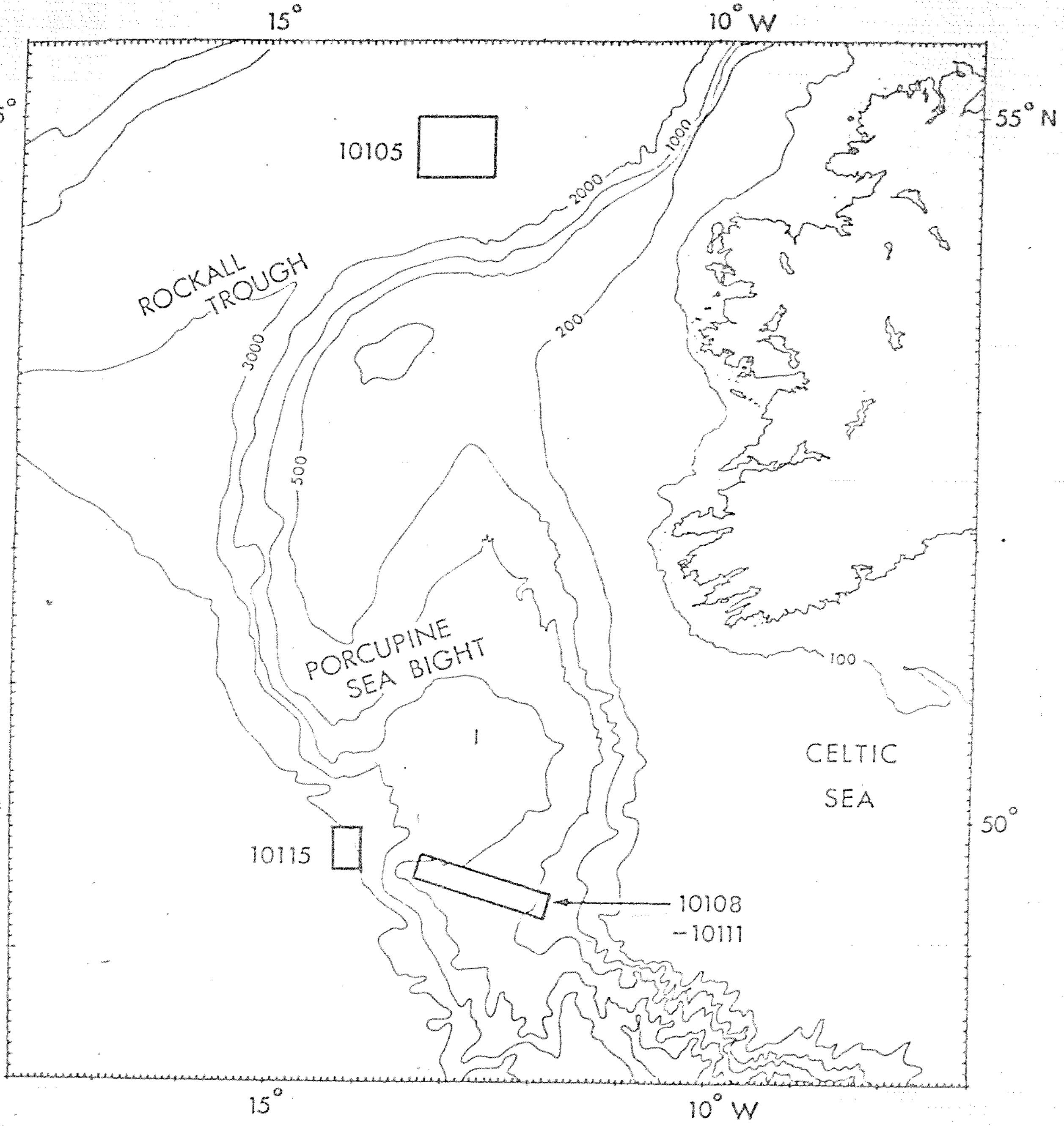

Fig. 1. Bathymetric chart showing the station positions in the Rockall Trough and the Porcupine Seabight (Discovery Cruise 105).

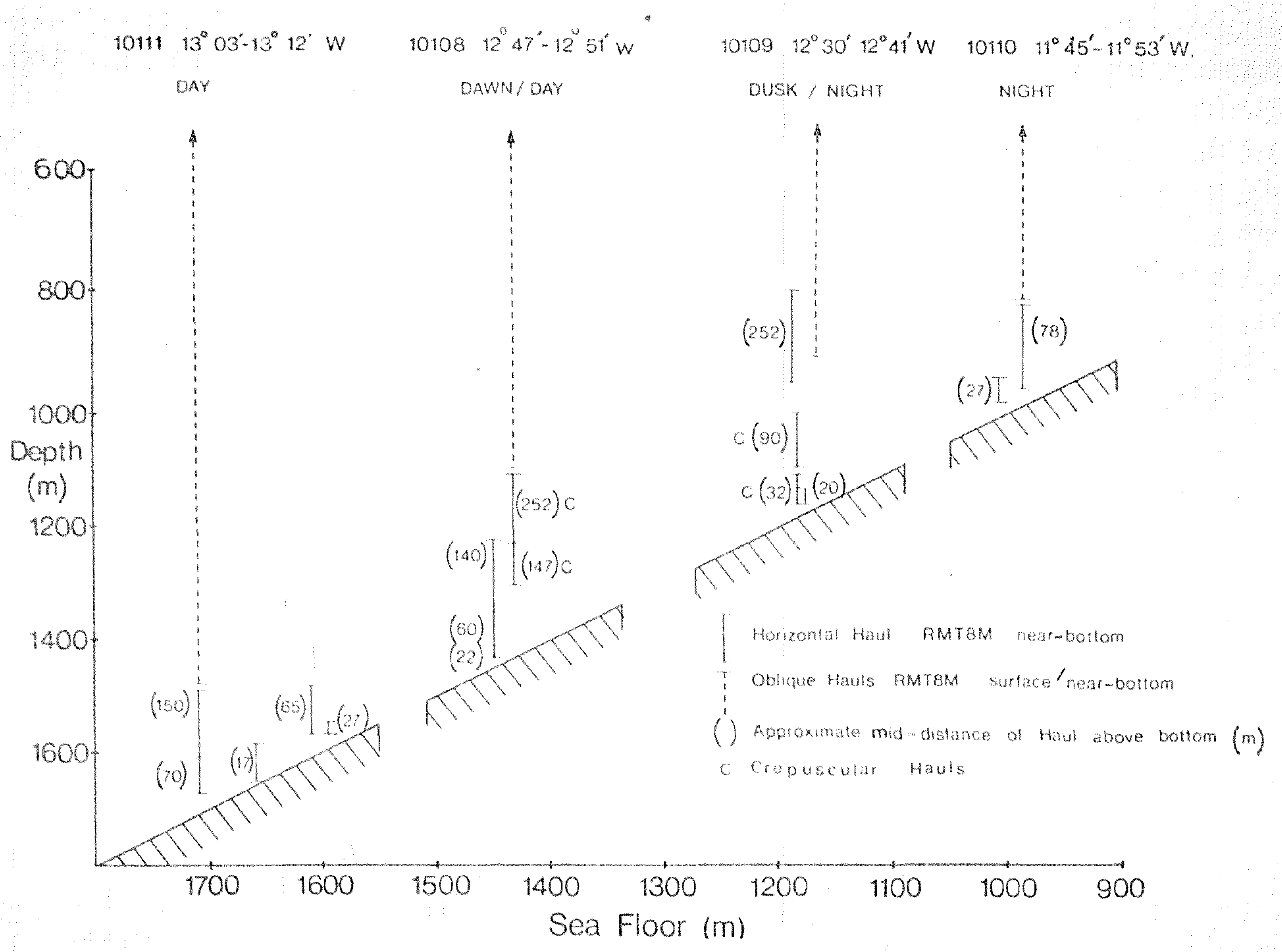

Fig. 2. Diagram showing the relative depths of the near-bottom hauls and oblique hauls taken over the slope at stations 10108-10111.

assess the height of the net above the sea floor. At each of the slope stations, in addition to the horizontal tows, an oblique tow was made from the shallowest depth sampled in the near-bottom tows up to the surface 10m, to check that there had been no substantial change in the near-surface communities.

At the two deep water stations in the Rockall Trough and the Seabight the top 900m of the water column was sampled both by day and by night in 100m strata. Each stratum was fished for approximately one hour at a towing speed of two knots. Below 900m it was assumed that there would be no significant diel vertical migration, (Angel et al., 1982) and at these depths 200m strata were fished for two hours irrespective of the light cycle. The maximum depth of sampling was 1900m in the Rockall Trough and 1500m in the Porcupine Seabight. Profile data from these two deep water stations, where applicable, were used as yardsticks by which the effect of the continental slope on the distributions of the midwater species could be assessed.

The physical structure of the water column was measured using a Neil-Brown conductivity, temperature, depth (CTD) probe to a depth of 2940m in the Rockall Trough, and 1900m in the Seabight. At each of the slope stations CTD observations were made to within 10m of the sea floor. Full station details are given in IOS Cruise Report 82, (Herring, 1979), and a summary of relevant station data is given in appendix A of this paper.

The samples were initially preserved in 5% formalin in sea-water, (100% formalin ≡ 40% solution of formaldehyde buffered with 6g ℓ^{-1} borax). On return to the laboratory the samples were transferred to Steedman's preserving fluid (Steedman, 1976), prior to sorting and voluming.

1.b. HYDROGRAPHIC CONDITIONS

Temperature - salinity (T-S) profiles for deep water stations in the Rockall Trough (Station 10105) and in the Porcupine Seabight (Station 10115) are plotted in Fig. 3. The comparison of these data with Ellett's data for the Rockall Trough (Ellett, personal communication) shows that although the temperature data are similar these salinity data are approximately 0.05‰ higher, probably the result of a minor instrumental error. The data are considered to be adequately accurate for the purpose of this paper. In the Seabight an almost isohaline surface layer extended down to just below 100m. Beneath this isohaline

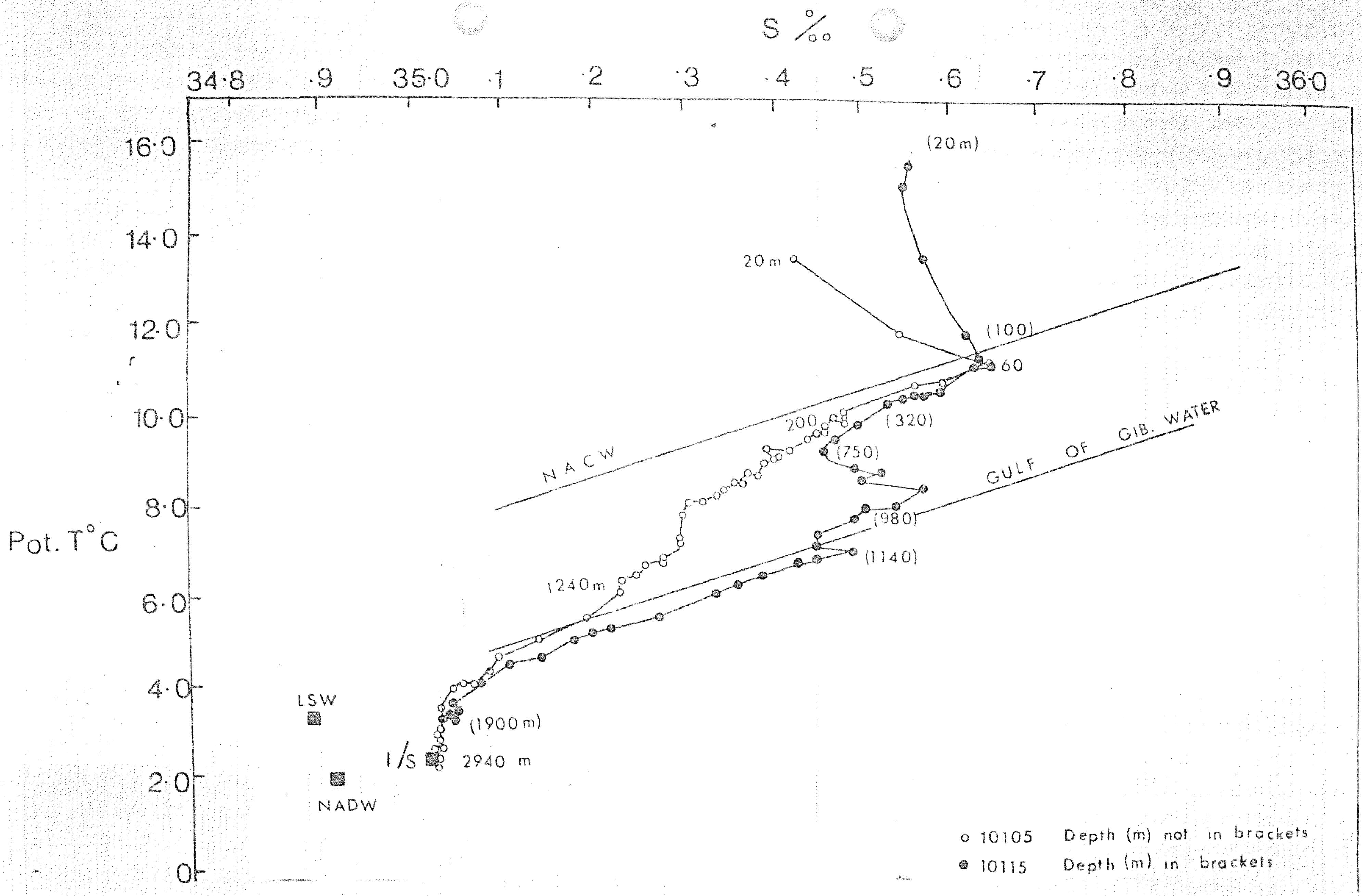

Fig. 3. Temperature/salinity profiles for the Rockall Trough (Station 10105) and the Porcupine Seabight (Station 10115). LSW = Labrador Sea Water. NACW = North Atlantic Central Water. NADW = North Atlantic Deep Water. I/S = Iceland - Scotland Overflow Water.

layer the T-S characteristics were typical of North Atlantic Central Water (NACW) as defined by Sverdrup, Johnson and Fleming (1942). Below 300m salinity increased relative to NACW and at 750-980m there was a salinity maximum below which salinity declined to values typical of Gulf of Gibraltar water. A secondary maximum occurred at about 1140m. At greater depths T-S values gradually approached closer to the characteristic values of Labrador Sea Water. Just above 1900m the lowest section of the T-S curve indicated the influence of Iceland/Scotland overflow water.

In the Rockall Trough the T-S values were generally lower than in the Seabight. There was a clearly distinguishable zone of typical NACW water at 60-200m overlying water with an enhanced salinity content which indicated the influence of Gulf of Gibraltar water. Close to the bottom the hydrographic characteristics were closer to Labrador Sea Water and the Overflow Water. T-S diagrams for the four slope stations are given in Fig. 4 and are generally similar to the deep water profiles from the Seabight. In Fig. 5 the data are compiled into a salinity section extending up the slope from the deep water station. The Gulf of Gibraltar salinity maximum occurred at between 900 and 1000m and was most pronounced at the central slope stations (10108-10109). The presence of this core of higher salinity water over the slope suggests that a northward current may have occurred there (Ellett, Dooley and Hill, 1979).

1.c RESULTS

1.c.1 Macroplankton and micronekton

A total of 60 RMT 8M and 33 RMT 1M samples were analysed. RMT 1M catches are time-consuming to analyse so effort has been concentrated on the near sea-bed samples (excluding the oblique hauls) from the slope stations and on the Porcupine Seabight deep water series (see Fig. 6). Even at this deep water station some groups (Chaetognatha, Polychaeta and Amphipoda) have only been examined from hauls below 800m. The RMT 1Ms from the Rockall Trough have not been examined in detail. All the RMT 8M samples from both deep water stations and from the slope stations have been analysed. The following sections look at biomass in RMT 8M and RMT 1M samples separately and then at the data for animal groups from appropriate nets.

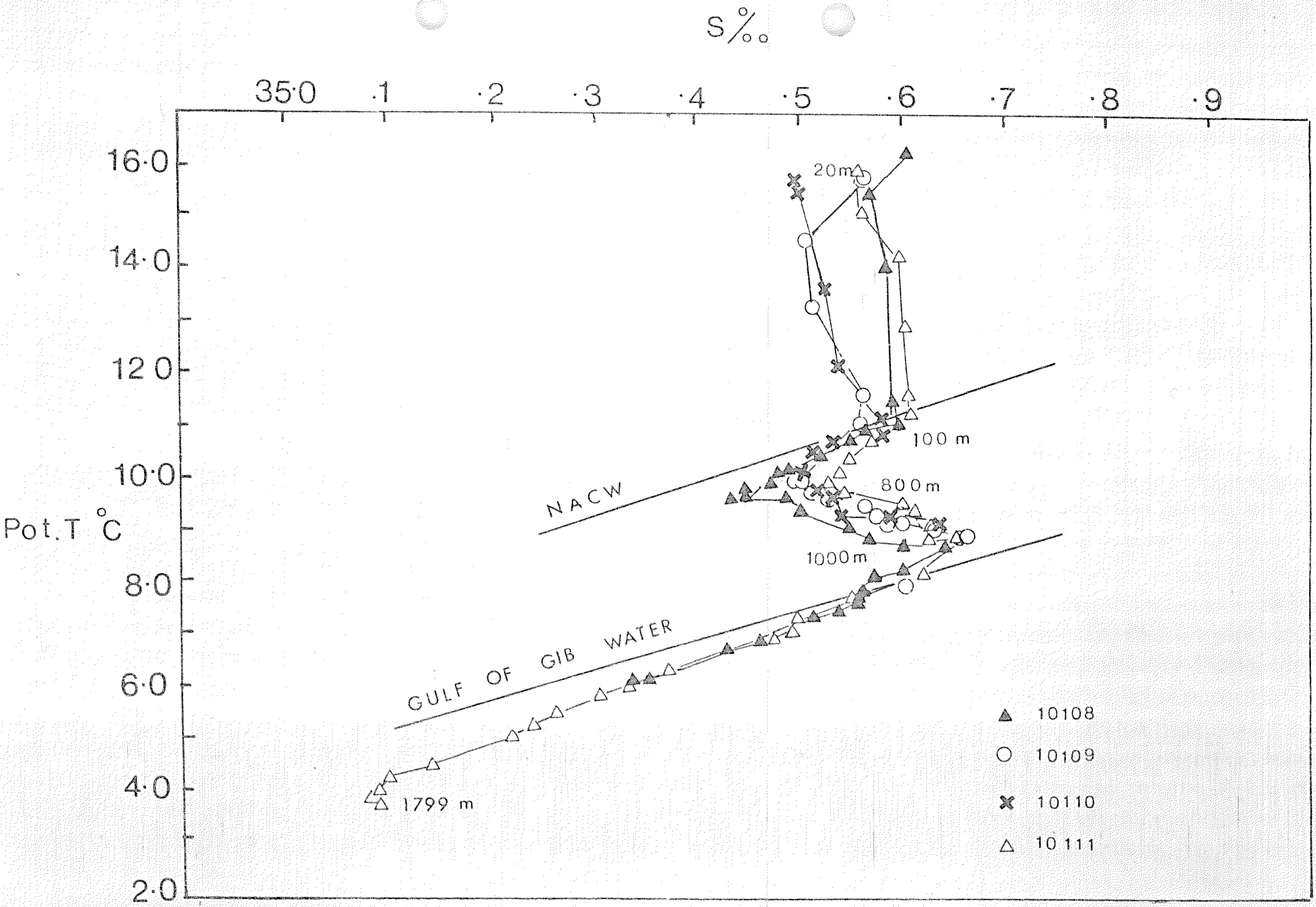

Fig. 4. Temperature/salinity diagram for slope stations 10108-10111.

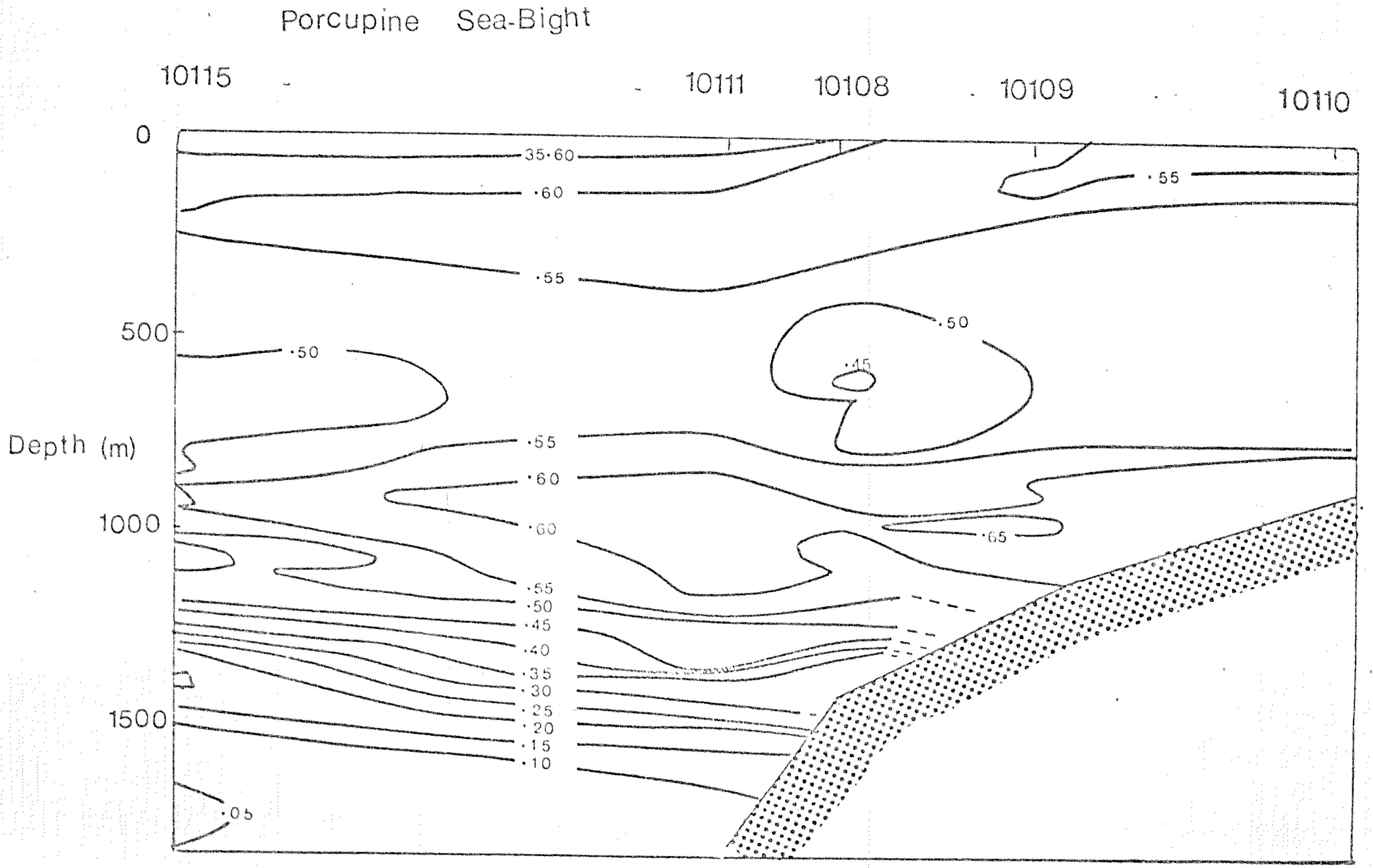

Fig. 5. Salinity section between Station 10115 and slope stations 10108-10111.

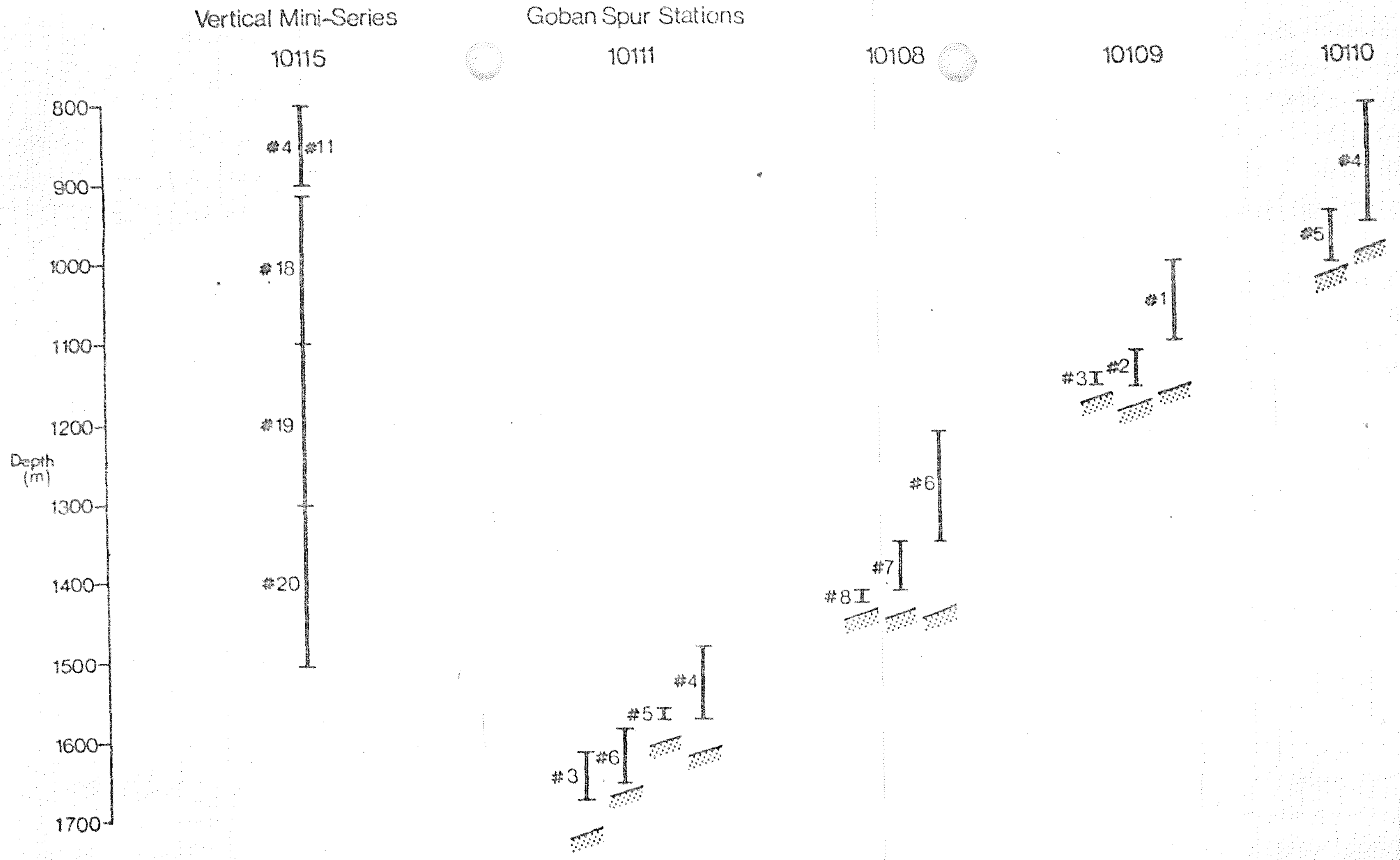

Fig. 6. Diagram showing the depth ranges of analysed RMT 1M hauls below 800m in the Seabight and over the slope at stations 10108-10111. Numbers for each haul are given. Depths of hauls are shown together with their relative height above the sea-bed; in subsequent diagrams absolute depths are plotted.

Table 1. Taxa analysed for numerical abundance and/or biomass from the macroplankton and micronekton samples collected during Discovery Cruise 105.

	Station 10105 10115 10108-10111	10115 10108-10111
Taxa	net RMT 8M	RMT 1M
Fish	+	–
Medusae	+	–
Siphonophora	+	–
Decapoda	+	–
Ctenophora	+	–
Mysidacea	+	–
Euphausiacea	+	–
Chaetognatha	+	+ *
Polychaeta	+	+ *
Copepoda	–	+
Ostracoda	–	+
Amphipoda	–	+ *

\+ Analysed

– Not analysed

* Below 800m at Stn. 10115

1.c.2 Biomass - Micronekton (Figs 7,8,9)

Values for RMT 8M total sample biomass, measured by wet displacement volume, are given in Fig. 7. Values for the near-bottom slope hauls are plotted according to sampling depth rather than height above the bottom to permit direct comparison with the deep water station data, consequently, there appears to be some overlap. Values plotted against average sampling height above the sea floor are shown in Fig. 8. In the Rockall Trough very little micronekton occurred in the top 100m by day; biomass concentrations peaked at 500-600m (22mℓs/1000m^3) and there was a further peak in the 1300-1500m haul (24mℓs/1000m^3). At night there was only a slight migration up into the surface 100m, consequently at 300-900m biomass concentrations were similar by day and by night. The very low night-time catch at 200-300m was probably an artefact caused by a gear malfunction.

By day in the Seabight biomass concentrations were variable with depth, values of >20mℓs/1000m^3 occurred in at least half of the hauls. The total integrated water column biomass was slightly greater in the Seabight than in the Rockall Trough. Below 500m biomass values were similar by day and by night, but there was evidence for the occurrence of some diel vertical migration. At night a high biomass concentration of about 50mℓs/1000m^3 occurred in the 10-100m haul, but below the surface 100m zone biomass concentrations steadily decreased to a depth of approximately 500m.

At the slope biomass concentrations were variable. At the shallowest station (10110) biomass was slightly higher than at comparable depths at the deep water stations but its concentration decreased slightly towards the bottom. At all the other three slope stations the biomass increased as the sampling approached the bottom. However, there was little difference between the biomass concentrations at the slope stations and comparable depths at the deep water stations (Fig. 7).

At the deep water stations each biomass maximum in the profiles was usually produced by the high abundance of a single taxonomic group e.g. siphonophores or medusae. Biomass profiles for each of the major taxonomic groups are shown separately below. The relative biomass of each group expressed as a percentage of the total biomass in each haul have been plotted (Fig. 9), to compare group

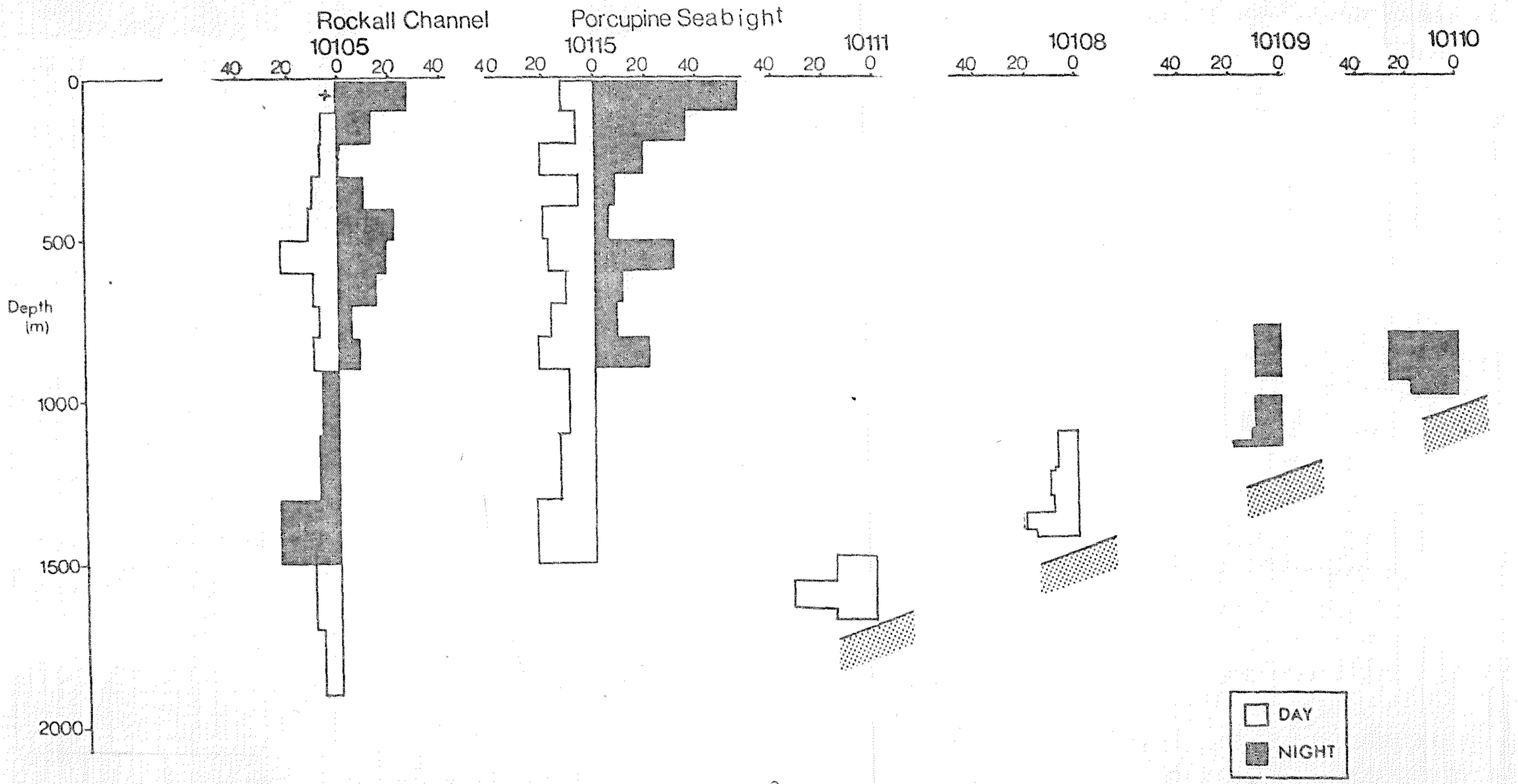

Fig. 7. Profiles of biomass (displacement volume mℓs/1000m^3) of total micronekton in RMT 8M samples at the deep water and slope stations. For all the hauls depths are given in metres but over the slope nets were fished according to height above the bottom, so that there is overlap in the sampling depths.

Catch displacement volumes ml/10^3m^3 (RMT 8)

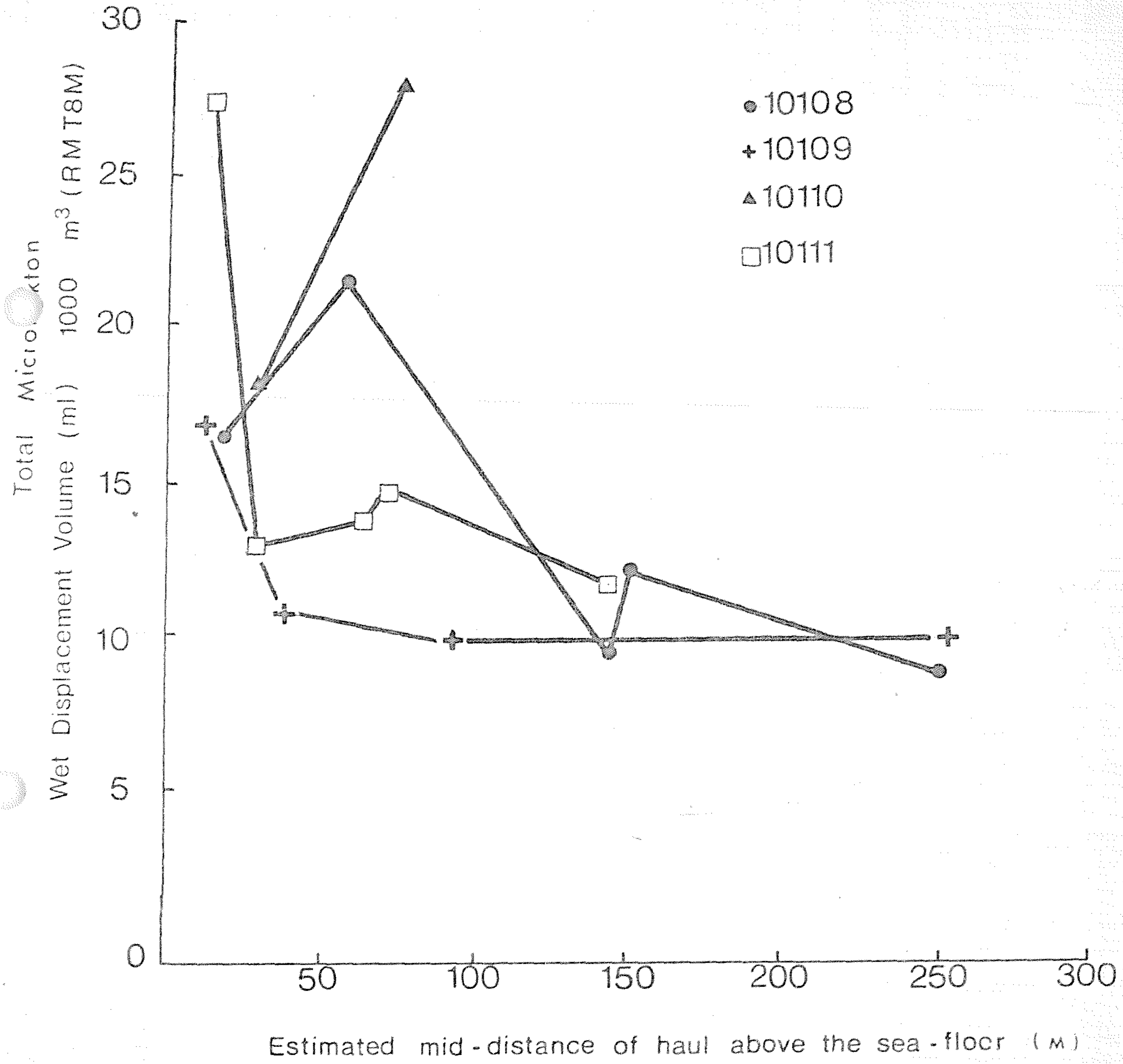

Fig. 8. Plots of the total sample of micronekton (RMT 8M) biomass (displacement volume mℓs/1000m^3) at the slope stations plotted against average distance of each haul in metres above the bottom.

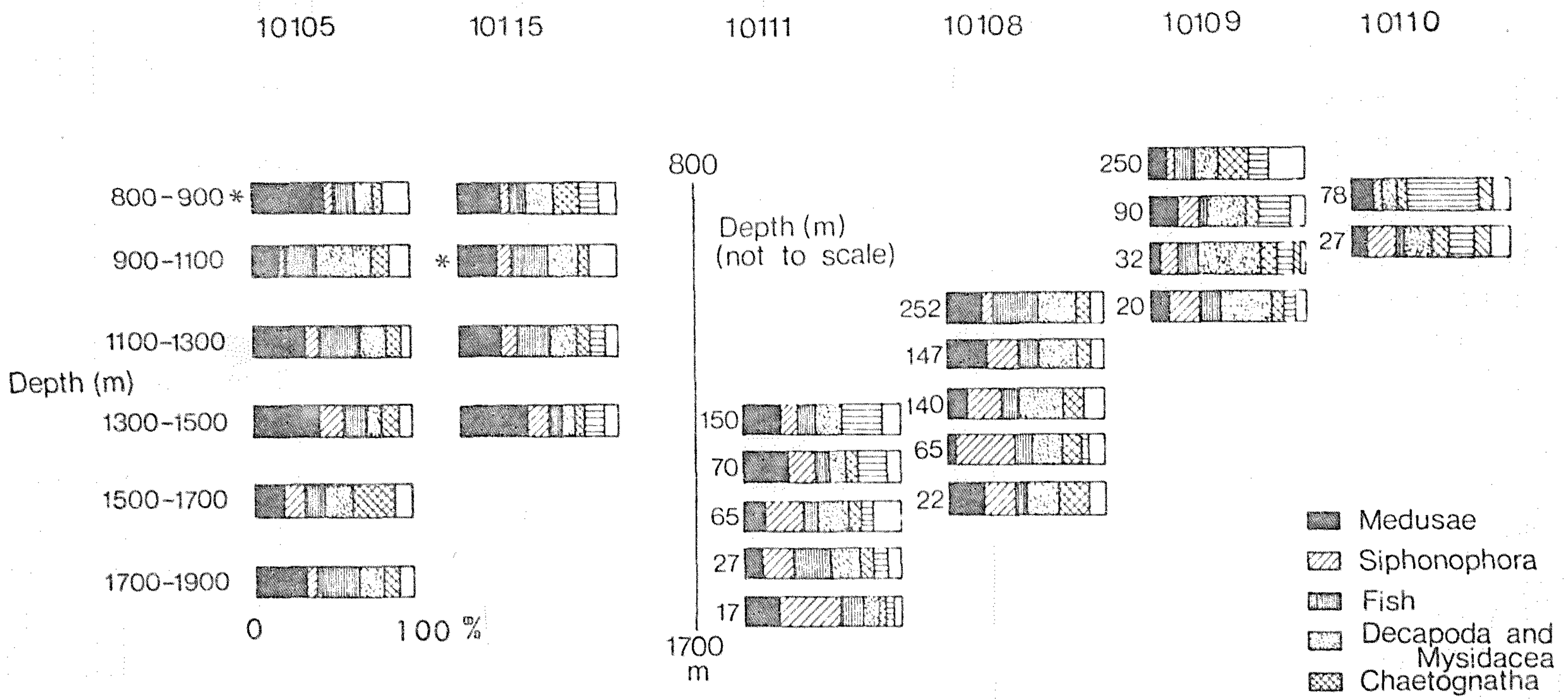

Fig. 9. Diagram to illustrate the relative importance of the biomass of eight dominant taxonomic groups, expressed as a percentage of the total micronektonic biomass (RMT 8M) in each haul in deep water in the Rockall Trough (Station 10105) and the Seabight (Station 10115) and at the slope stations 10108-10111. The values shown against the bar plots for the slope stations are the average haul height above the bottom in metres.
* excludes small coelenterates.

dominance near-bottom over the slope with group dominance at the deep water stations below 800m (excluding the 800-900m night hauls). While it is acknowledged that the displacement volume estimate of biomass is inaccurate because shrinkage during preservation varies not only between groups but also between species, the changes that occur down through the water column are so large that this crude method does provide a useful indication of the changes in relative importance of the various groups.

In most hauls below 800m at the deep water stations Medusae were an important component of the catch, and similarly over the slope this group was dominant in some hauls although their contribution to the total sample biomass tended to be slightly lower than at the deep water stations; values ranged from 6%-30% over the slope and from 16%-45% at the deep water stations below 800m. Siphonophores tended to form a greater percentage of the biomass near-bottom over the slope than over deep water and they were a particularly important part of the catch at the deep slope stations 10108 and 10111 where they comprised 12%-40% and 16%-40% respectively of the near-bottom catches.

In the slope hauls pelagic fish biomass varied considerably, but apart from at Station 10110, contributed a moderate proportion of the sample biomasses. However, fish biomass concentrations tended to be slightly lower over the slope than at the deep water stations possibly because of competition by bentho-pelagic fishes not sampled by the RMT 8M. Data for Decapoda and Mysidacea have been grouped together in Figure 9. Below 800m over deep water these groups together comprised 9%-20% of the catch except in one sample in which they provided 34%. Over the slope their importance was often much greater where their contribution equalled or exceeded 20% in the near-bottom hauls at Stations 10108 and 10109; in one haul at the latter station they provided 43% of the sample biomass. Chaetognatha were present throughout; at the deep water stations they provided 4%-22% of the biomass and 4%-25% for the slope hauls. The highest values of 19% and 25% were in the shallowest haul at Station 10109 and the nearest bottom haul at Station 10108. Ctenophora were not abundant in the Rockall Trough, but they were quite abundant at the Seabight deep water station. Over the slope they were particularly important at the shallowest station (10110) where they formed 47% and 18% of the biomass of the two hauls. Polychaeta were important at the shallowest slope station (10110) where they formed at least 10% of the biomass in each haul.

1.c.3 Biomass - Macroplankton

The RMT 1M macroplankton catches often include a few micronektonic animals which can form a significant percentage of the catch displacement volume. In one deep water Seabight haul a fish of 40mℓ and a medusa of 60mℓ between them comprised a quarter of the total catch volume. Consequently the displacement volumes of the RMT 1M samples were measured after the removal of these large animals i.e. animals with displacement volumes >1mℓ. As for the micronekton data, the plankton volumes have been corrected to mℓs/1000m^3, and have been plotted against depth in Figure 10. In general the concentration of macroplankton is greater than that of micronekton (Angel and Baker, 1982).

In the Seabight the effects of diel vertical migration within the top 600m of the water column are clear. Between 600-1300m the day and night haul biomasses were fairly constant at 20-30mℓ/1000m^3 but declined to 14mℓ/1000m^3 at 1300-1500m.

At the deepest slope station (10111) the biomass in the haul fished closest to the sea-bed was three times greater than both, at the equivalent depth over deep water, and in a haul which was fished within 40m of bottom. There was a similar threefold increase in plankton biomass in the sample taken closest to the sea-bed at Station 10108 compared to the equivalent deep water sample. However, there was a slight increase in the observed planktonic biomass at 90-30m above the bottom, but a sharp decline at 90m above. At Station 10109 there was yet again a threefold increase in plankton biomass in the two samples from closest to the sea-bed compared both with higher in the water column and over deep water, and this was repeated at the shallowest slope station (10110) but to a lesser degree. Thus at all four slope stations the biomasses in hauls taken within a few metres of the bottom were about three times greater than at comparable depth over deep water only a short distance from the slope.

Generally in water of such depths sample error is less than a factor of two (Angel et al., 1982). Hence despite the lack of replicate sampling this observed increase in plankton standing crop close to the sea-bed is unlikely to be a sampling artefact particularly as the effect was repeated at all four slope stations. Moreover, as can be seen for the total counts for ostracods, copepods, chaetognaths and polychaetes presented in Table 2, similar trends

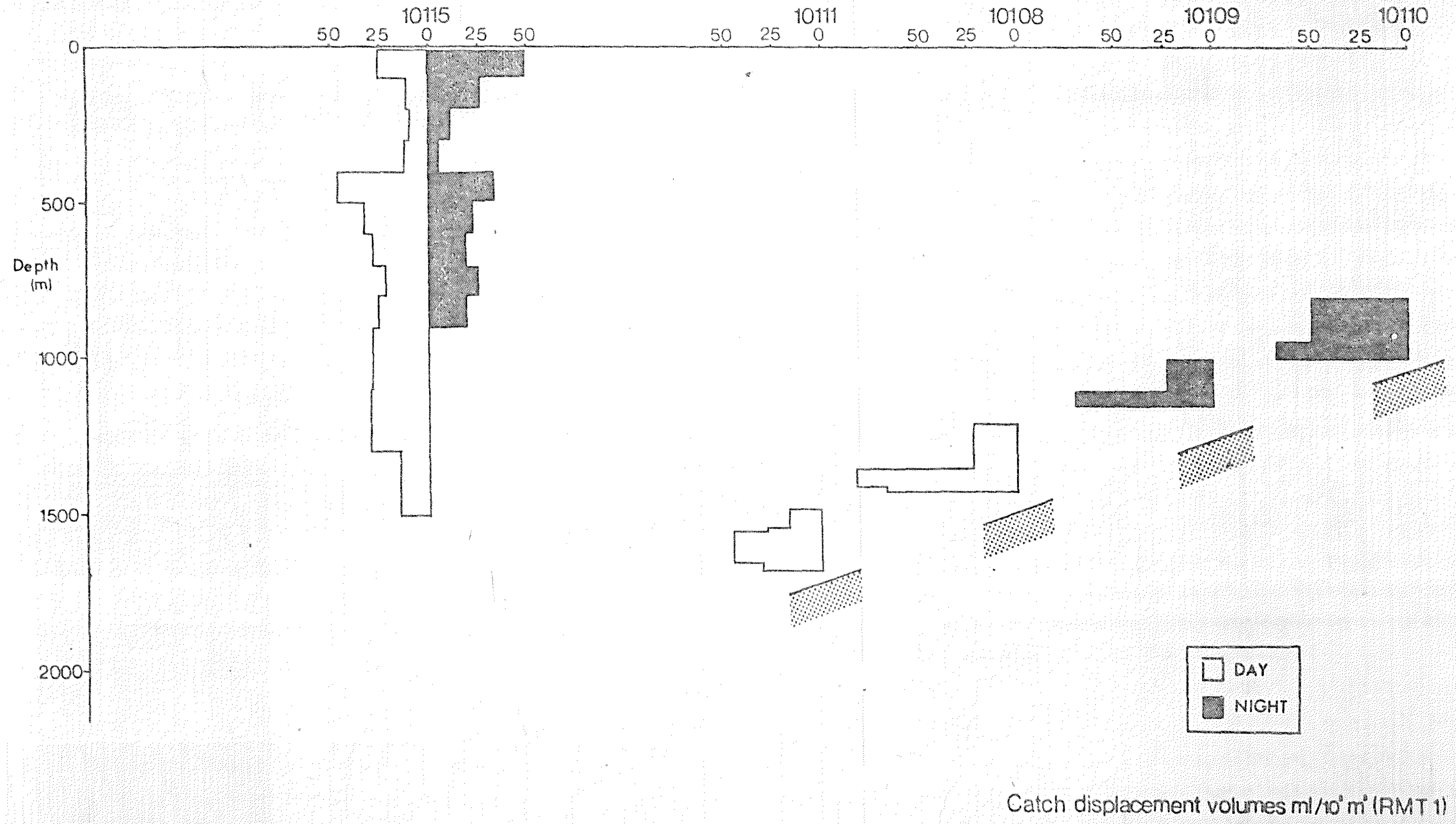

Fig. 10. Profiles of biomass (displacement volume mℓs/1000m^3) of total macroplankton in RMT 1M samples at the Seabight deep water and slope stations. For all the hauls depths are given in metres but because over the slope nets were fished according to height above the bottom, there is some overlap in the sampling depths.

Table 2. Macrozooplankton catch displacement volumes and numbers of animals of five taxa per 1000m^3 for 33 hauls from the Porcupine Seabight.

Station # haul	Depth (m)	Total catch displacement volume per 1000m^3	Numbers of animals per 1000m^3					Metres above bottom
			Ostracoda	Copepoda	Chaetognatha	Polychaeta	Amphipoda	
Porcupine Seabight vertical mini-series in deep water								
DAY HAULS								
10115#15	10-100	26	1262	82925				
#16	100-200	11	8503	38092				
#17	200-300	10	4024	17989				
# 5	300-400	12	1644	15595				
# 6	400-500	46	3245	32254				
# 7	500-600	33	1391	39939				
# 2	600-700	28	1545	39277				
# 3	700-800	22	912	20794				
# 4	800-900	25	1080	20813	823	55	13	
#18	910-1100	28	411	29723	286	224	13	
#19	1100-1300	29	748	30352	413	54	8	
#20	1300-1500	14	366	17243	218	20	6	
NIGHT HAULS								
10115#21	10-100	50	2191	146204				
#22	100-200	27	7814	34900				
#23	195-300	12	2635	14734				
#12	295-400	6	1688	8332				
#13	400-500	34	2549	16857				
#14	500-600	24	1443	29337				
# 9	600-700	20	1328	22952				
#10	700-800	26	1838	24622				
#11	800-900	20	941	21812	813	54	7	

Table 2 continued

Station # haul	Depth (m)	Total catch displacement volume per 1000m^3	Numbers of animals per 1000m^3					Metres above bottom
			Ostracoda	Copepoda	Chaetognatha	Polychaeta	Amphipoda	
Near-bottom hauls, Goban Spur slope stations								
10111#4	1480-1570	17	236	18739	129	118	8	40-90
#5	1555-1570	28	369	34759	158	582	10	25-30
#6	1580-1650	45	515	51034	143	631	21	10-25
#3	1610-1670	31	328	39786	204	368	11	100-40
10108#6	1210-1350	22	498	25540	232	5	11	To within 90m
#7	1350-1410	83	1141	87784	409	15	8	90-30
#8	1410-1425	67	1158	101216	363	702	15	30-15
10109#1	1000-1100	24	587	28305	370	17	6	To within 60m
#2	1100-1155	71	990	72667	524	36	4	60-25
#3	1140-1155	64	873	62904	355	110	9	25-15
10110#4	800-900	51	1692	55935	565	130	8	120-35
#5	935-1000	69	1650	64309	347	265	11	40-15

occurred in the abundances of the numerically dominant groups. Only in the amphipods which were not numerically abundant in the samples was the effect less apparent.

1.c.4 Fish (Figs 11, 12, 13)

The vertical profiles of numerical abundance of pelagic fish at the two deep water stations are similar in pattern. Slightly higher concentrations occurred in the Seabight (Fig. 11), where at least part of the fish population undertook diel migrations; by day there was a peak in abundance at 500-600m (16 specimens/1000m^3) whereas at night the peak occurred in the surface 100m (34 specimens/1000m^3). At 300-1000m the biomass profiles at both deep water stations were roughly similar to the profiles of abundance, except at 500-600m in the Rockall Trough where the biomass maximum was not reflected by a peak in numerical abundance. However, below 1000m biomass increased relative to numerical abundance particularly in the 1300-1500m hauls (Fig. 12). Over the slope there was considerable variation in fish abundance and biomass, but the trends were similar in showing an increase with increasing proximity to the sea floor (Fig. 13).

Generally both the abundances and the biomasses of the pelagic fish tended to be slightly higher over the slope than in deep water. This is slightly unexpected since the presence of the benthopelagic fish community unsampled by the RMT 8M might have been expected to depress the pelagic populations. The Institute of Oceanographic Sciences has been conducting an extensive survey on the ecology and seasonal distribution of the benthopelagic fishes in the region and once this is completed, it may be possible to show how the two fish communities interact.

1.c.5 Medusae (Figs 14, 15, 16, 17)

The vertical abundance profiles of medusae taken in the RMT 8M samples from two deep water stations (Figs 14, 15 and 16) are relatively consistent in pattern. The abundance profiles showed no evidence of migratory behaviour. There was a minor peak in abundance at 500-600m and a more intensive maximum at 900-1500m. From the biomass profiles it can be seen that the shallower abundance peaks were formed by large forms, mostly Atolla wyvillei, which had large displacement volumes, whereas the deeper more extensive numerical abundance peaks consisted of much smaller organisms, mostly Aglantha digitale. The slope samples all

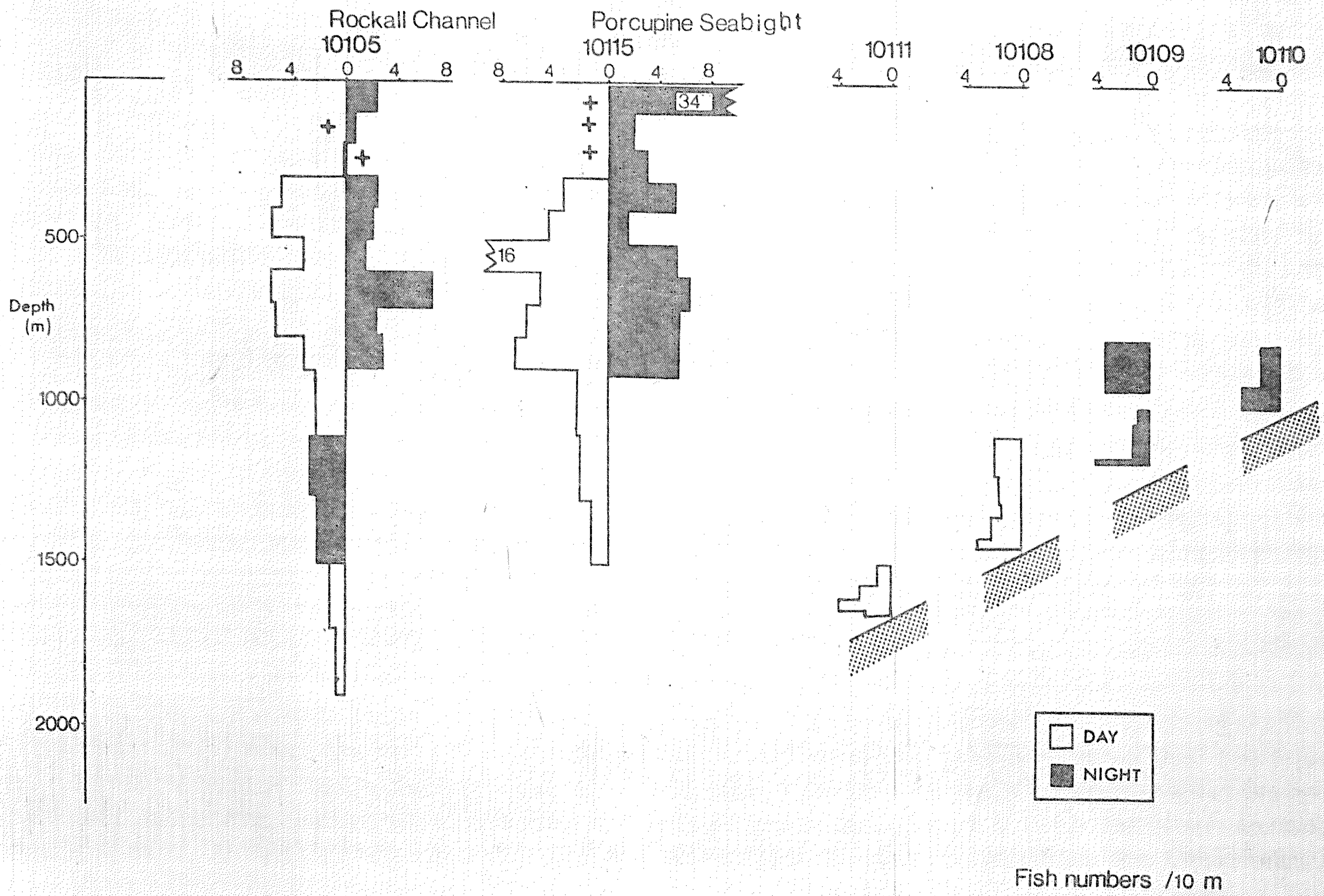

Fig. 11. Profiles of numerical abundance (Nos./1000m^3) of fish in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

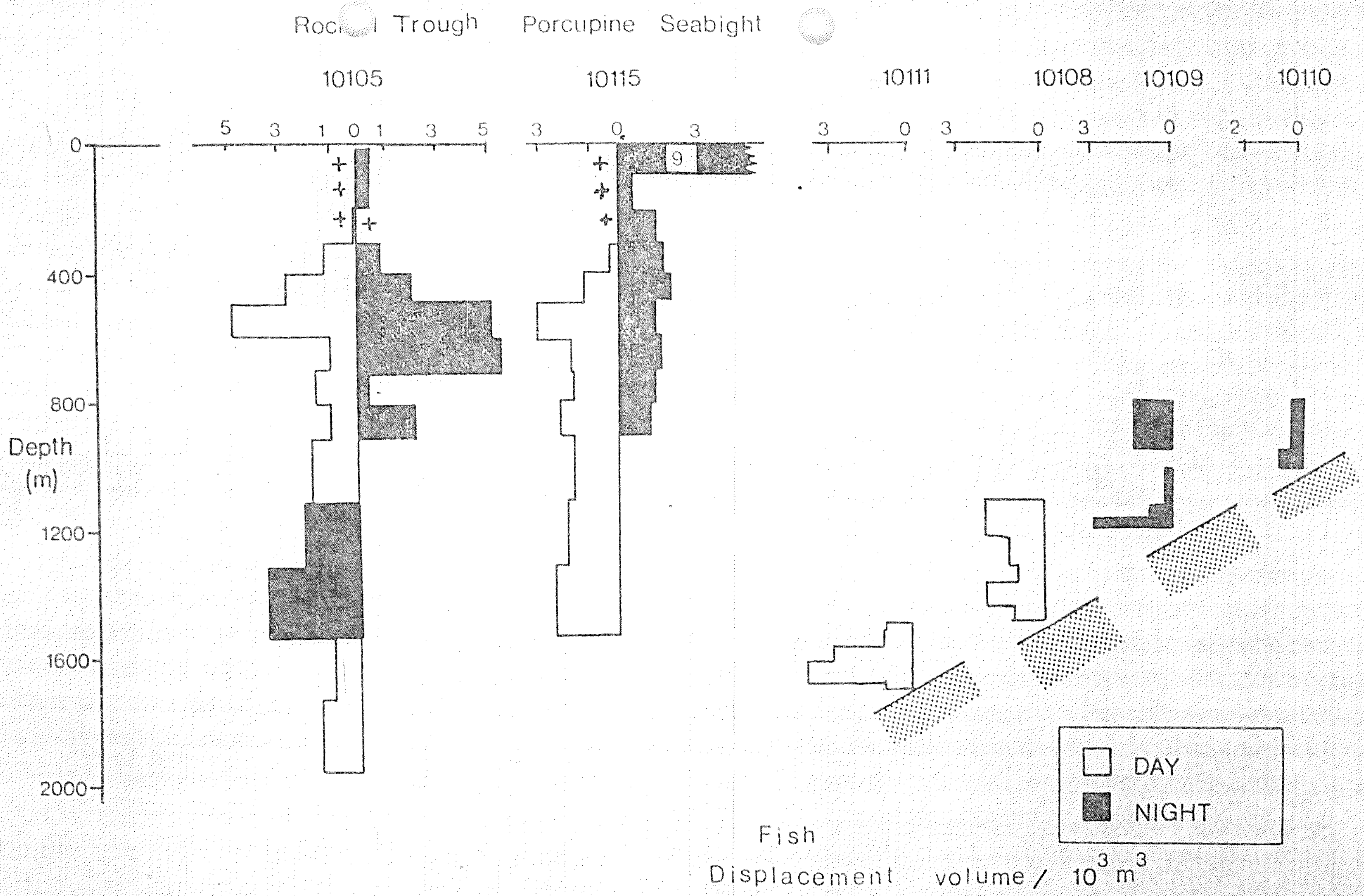

Fig. 12. Profiles of biomass (displacement volume mℓs/1000m^3) of fish in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

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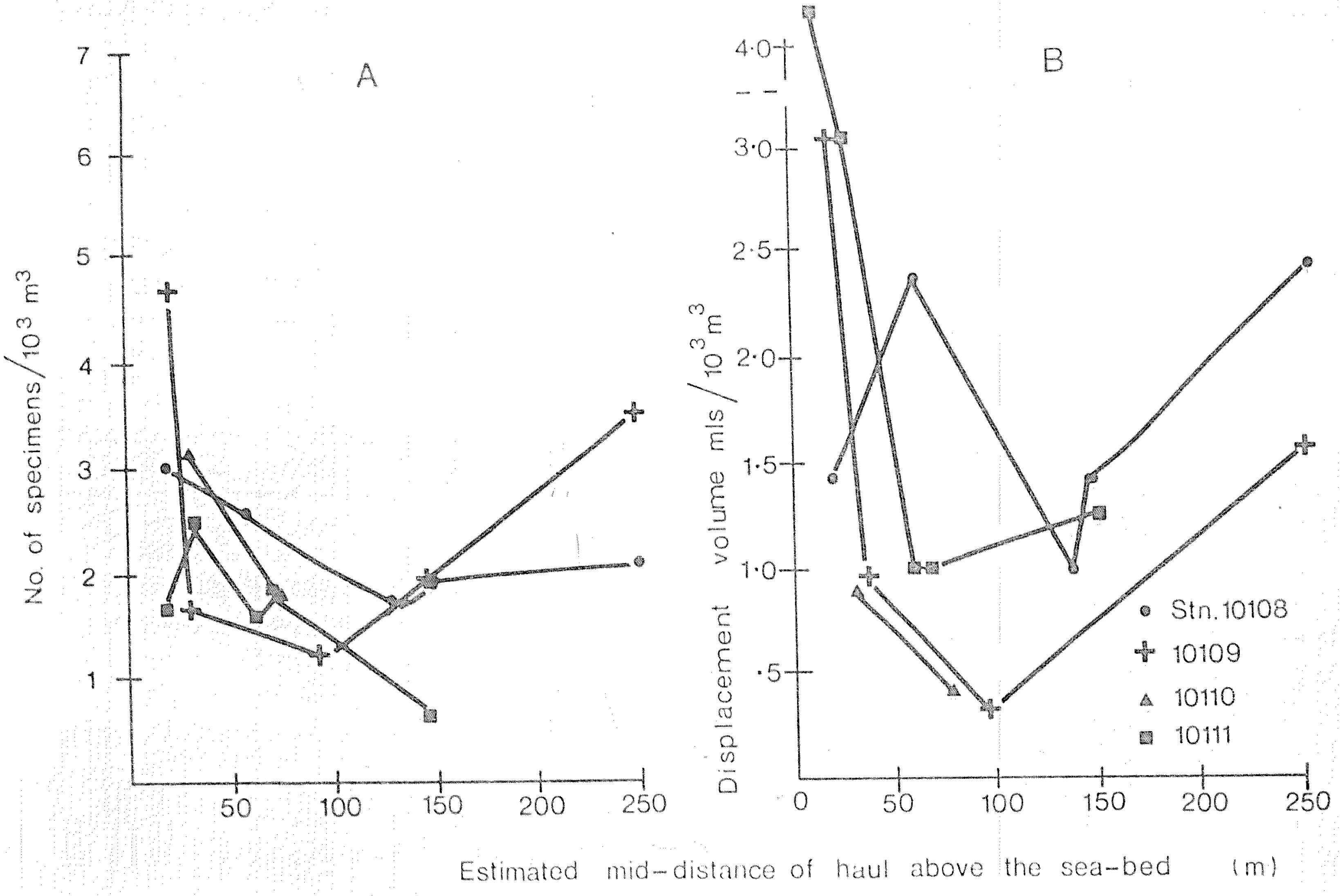


Fig. 13. Fish at slope stations: A. Numerical abundance and B. biomass concentration plotted against average distance above the bottom in metres (RMT 8M).

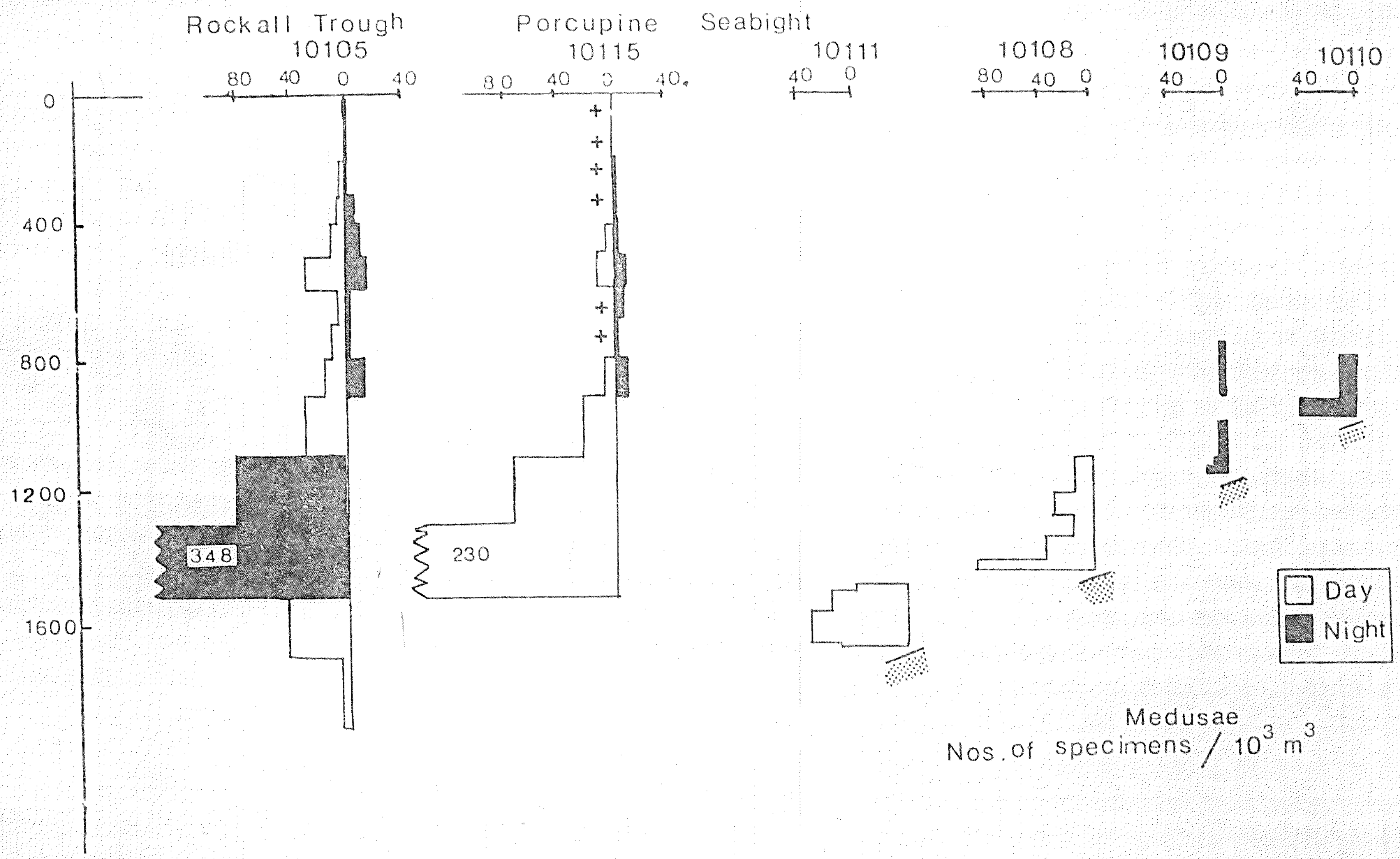


Fig. 14. Profiles of numerical abundance (Nos./$1000m^3$) of Medusae in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

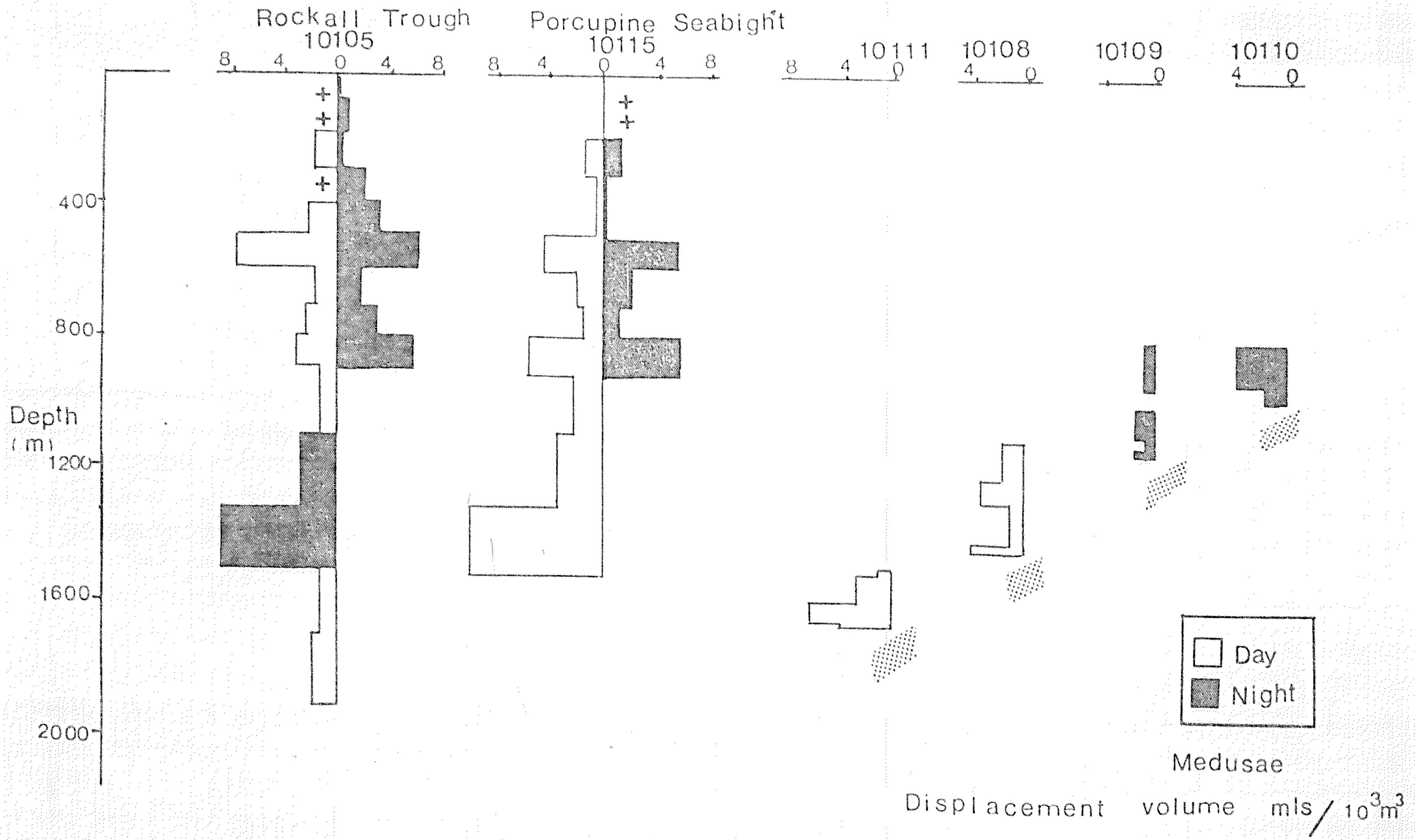


Fig. 15. Profiles of biomass (displacement volume mls/1000m^3) of Medusae in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

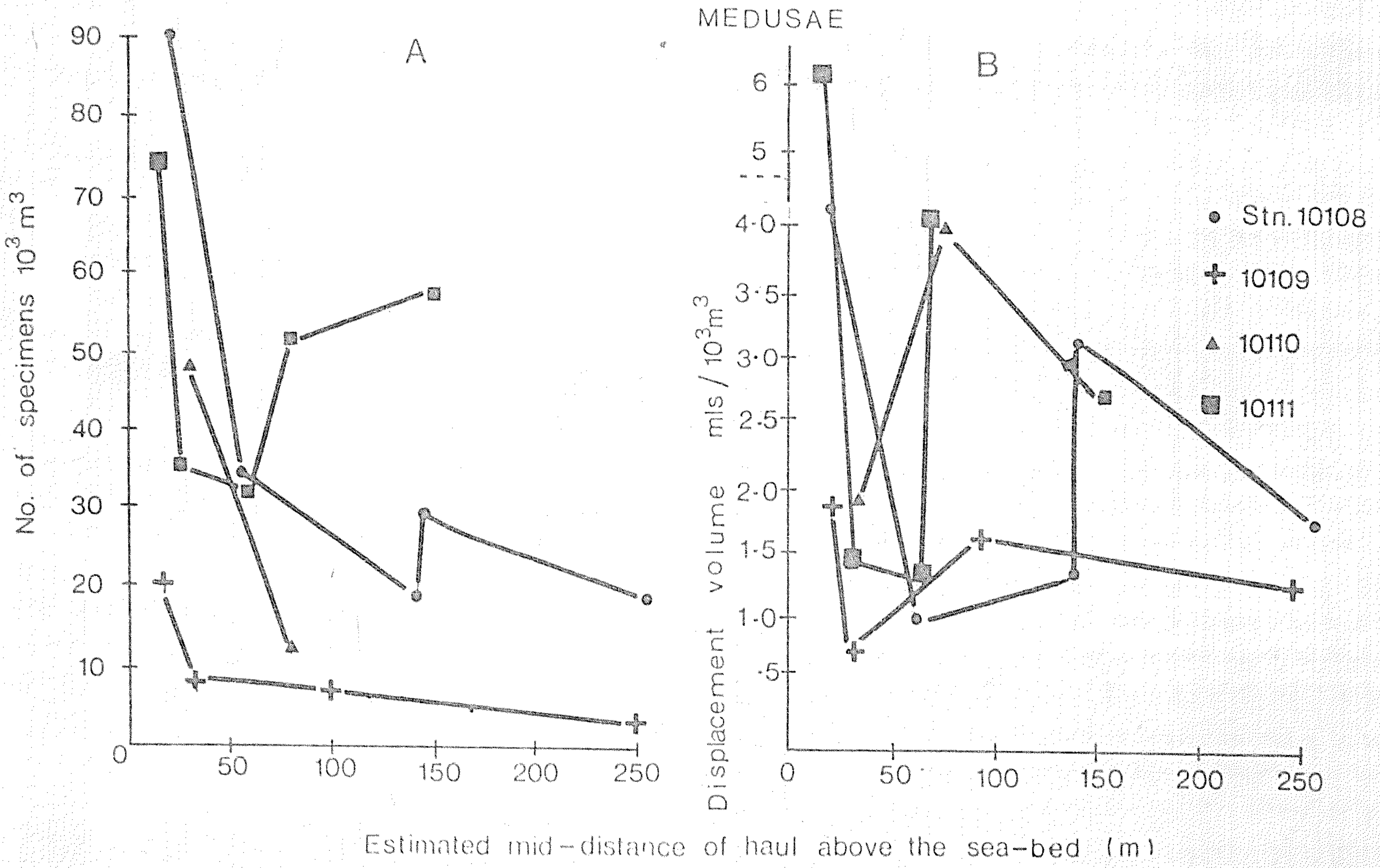


Fig. 16. Medusae at slope stations: A. Numerical abundance and B. biomass concentration plotted against average distance in metres above the bottom (RMT 8M net).

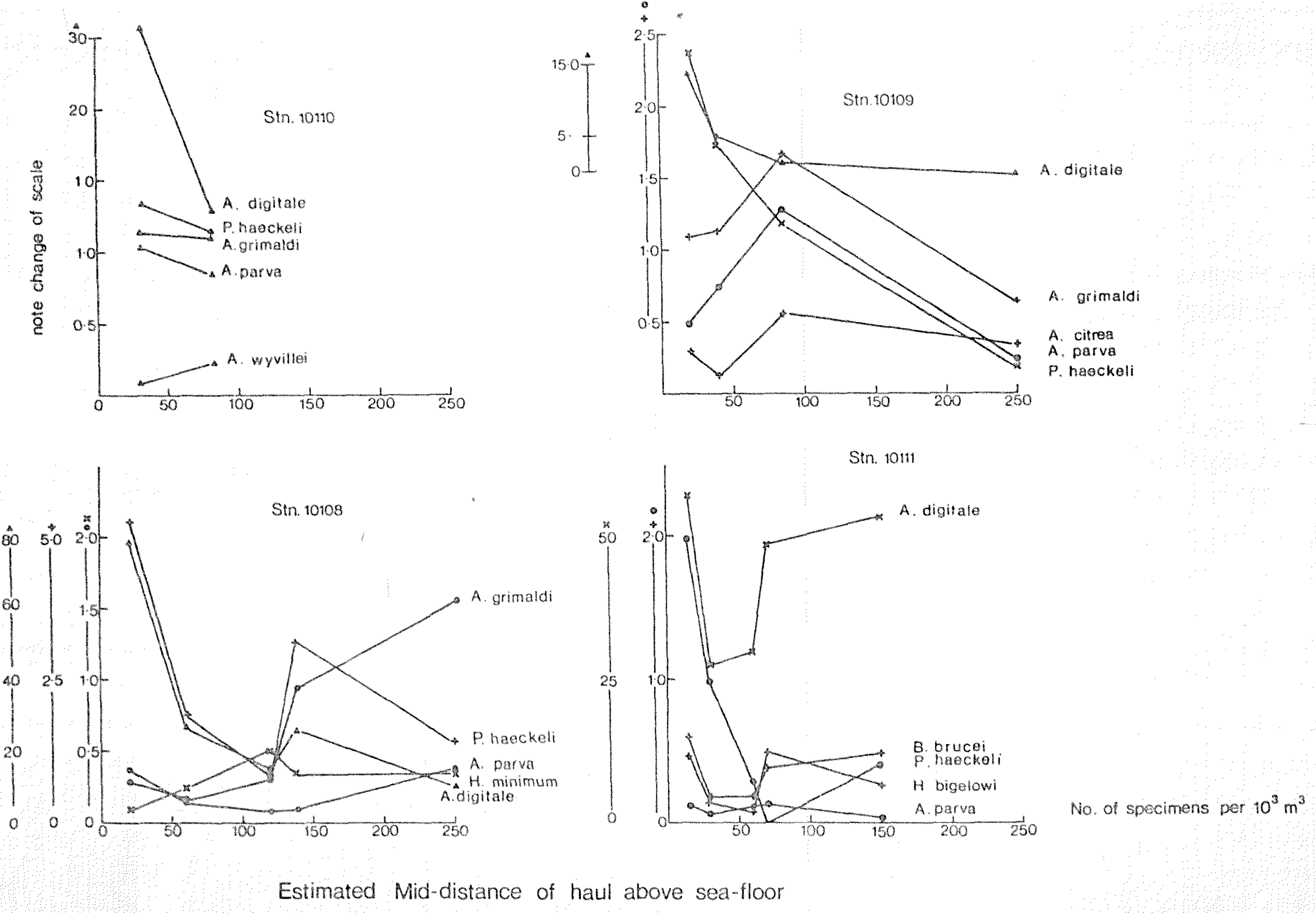


Fig. 17. Medusae at slope stations: Numerical abundance (Nos./1000m^3) of various species plotted against average distance in metres above the bottom (RMT 8M).

showed numerical abundances increasing quite sharply in close vicinity of the sea-bed, whereas the biomass trends are much less clear, except possibly at the deepest slope station (10111). At the shallowest slope station four of the five most abundant species increased in number as the sea-bed was approached. The exception was the large species Atolla wyvillei.

At Station 10109, the situation was more complex. The two dominant medusae Aglantha digitale and Pantachogon haeckeli increased in abundance in close proximity to the sea-bed. Whereas the other three common species, Aeginura grimaldi, Atolla parva and Aegina citrea, increased in abundance from 250-100m above the sea-bed, but then declined in abundance as the sampling got closer.

At Station 10108 two of the dominant species showed marked increases in abundance close to the sea-bed, i.e. Pantachogon haeckeli and Aglantha digitale. A. digitale reached densities of nearly 80/1000m^3 close to the sea-bed. In contrast Atolla parva, Aeginura grimaldi and Halicreas minimum appeared not to respond to the proximity of the sea-bed (Fig. 17). At the deepest slope station (10111) most of the species became more abundant in the lower trio of hauls as the sampling approached the bottom. However, the two hauls from higher in the water column contained almost as many specimens of most species as the sample collected closest to the bottom.

1.c.6 Siphonophora (Figs 18, 19)

Siphonophora are widely distributed in the Atlantic Ocean, (Pugh, 1974, 1975; IOS Biological Data Bank). Only a very rough estimate of the population biomass can be obtained by measuring the wet displacement volumes because they are subject to considerable shrinkage on preservation. Similarly because individuals of some species are composed of a variable number of component structures into which they readily fragment, it is not even possible to arrive at numerical estimates which are at all accurate. At both deep water stations peaks in biomass and abundance occurred at 500-600m and there were secondary peaks at 1300-1500m (Fig. 18). There was no evidence of the occurrence of significant diel vertical migration in the biomass profile data. At the slope stations, biomass estimates were similar to those from the deep water stations (Fig. 19) in hauls farthest from the bottom, but there was quite a substantial increase close to the bottom at the deeper two slope stations (10108-10111). At both these stations the near-bottom biomass concentrations were somewhat higher

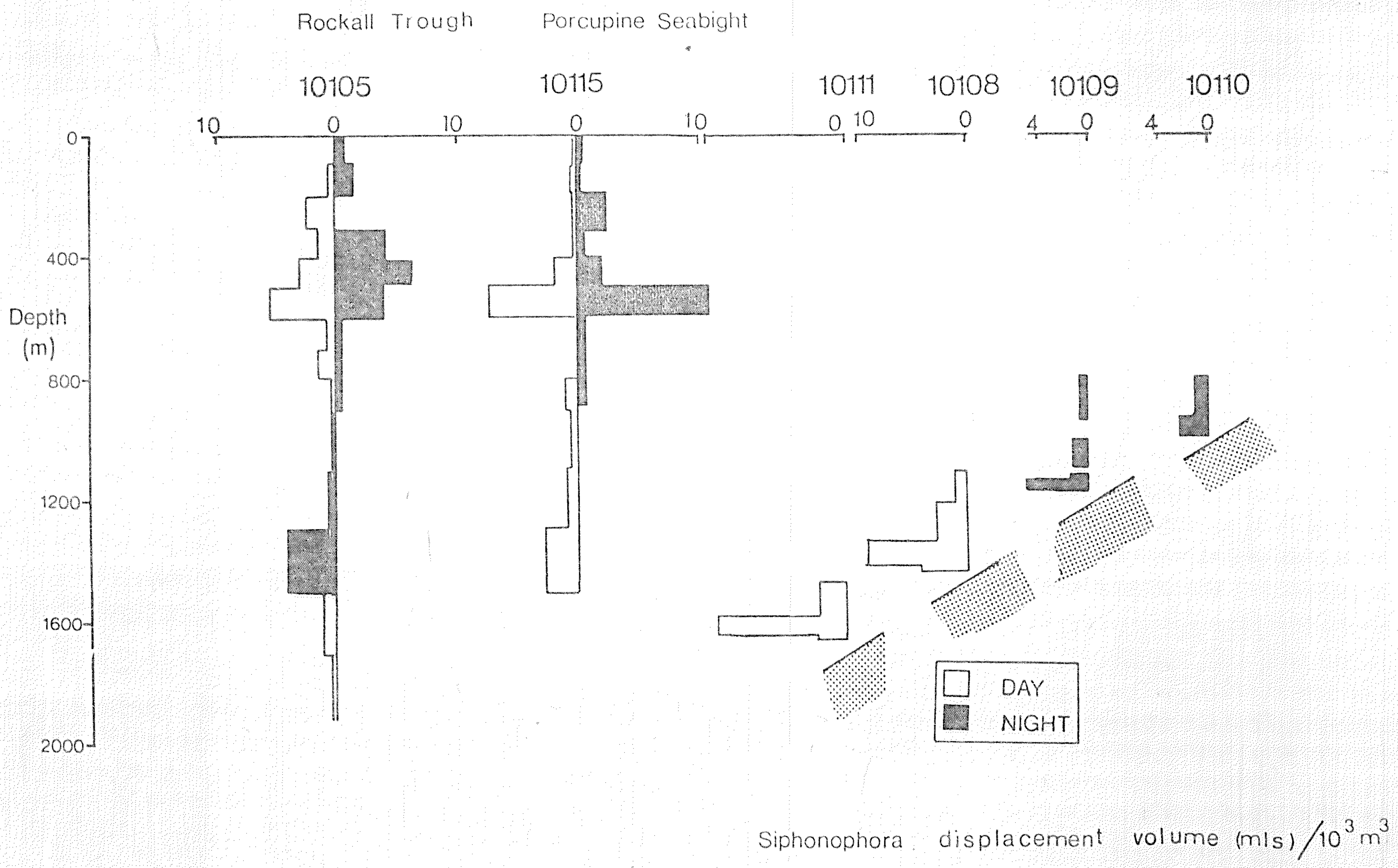


Fig. 18. Profiles of biomass (displacement volume mℓs/1000m^3) of Siphonophora in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

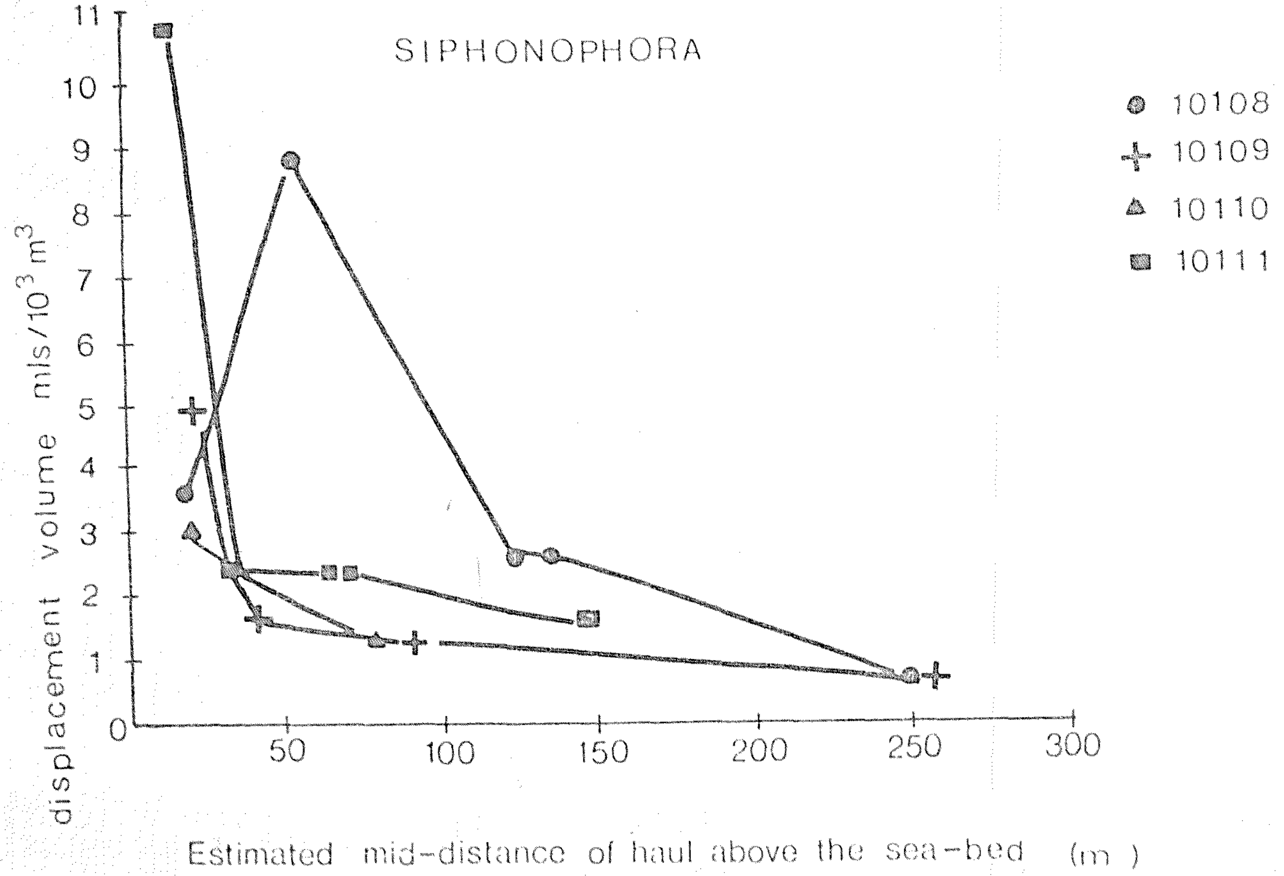


Fig. 19. Siphonophora at slope stations: biomass (displacement volume mls/1000m^3) plotted against average distance in metres above the bottom (RMT 8M).

than over deep water; particularly at the deepest station (10111) where the siphonophore standing crop was three times that observed at a comparable depth in the Rockall Trough. There were three dominant species in the slope hauls, Lensia conoidea which reached peak numbers at about 100m above the bottom and Dimophyes arctica and Chuniphyes multidentata showed a general increase in abundance towards the bottom.

1.c.7 Ctenophora (Figs 20, 21)

The Ctenophora were represented solely by the species Beroe cucumis. Very few specimens were caught in the Rockall Trough. At the Seabight station the daytime distribution was patchy; the maximum concentration was 1.3 specimens/ $1000m^3$ at 1300-1500m (Fig. 20). At night it was found mainly in the top 200m at concentrations of up to 4.0 specimens/$1000m^3$ at 100-200m suggesting an extensive vertical migration occurred. Concentrations at most of the slope stations were low except at the shallowest station where a concentration of 3.6 specimens/$1000m^3$ occurred in the haul farthest from the bottom and there was a sharp reduction in concentration nearer the sea floor. At the three deeper slope stations concentrations were very low but there was a consistent trend for abundance to increase close to the bottom (Fig. 21). As with siphonophores and other gelatinous forms, considerable shrinkage occurs on preservation making displacement volume a poor method of estimating ctenophore biomass. However, displacement volumes were roughly proportional to numerical abundance throughout.

1.c.8 Copepoda (Fig. 22)

Copepod data are based solely on the RMT 1M samples. Copepods dominate the macroplankton both in terms of standing crop and numbers, generally occurring at densities of $>20/m^3$; for example at night in the shallowest sample at the Seabight station there were $>146/m^3$. The abundances have had to be based on subsamples of the catch, obtained using the Folsom splitter. This device can introduce a subsampling error which is not always trivial compared with the variation between samples, (van Guelpen, Markle and Duggan, 1982), but as these authors remark it remains a necessary evil.

The slope samples contained significantly larger numbers of copepods than occurred in the equivalent samples from the deep-water station. Also, at all

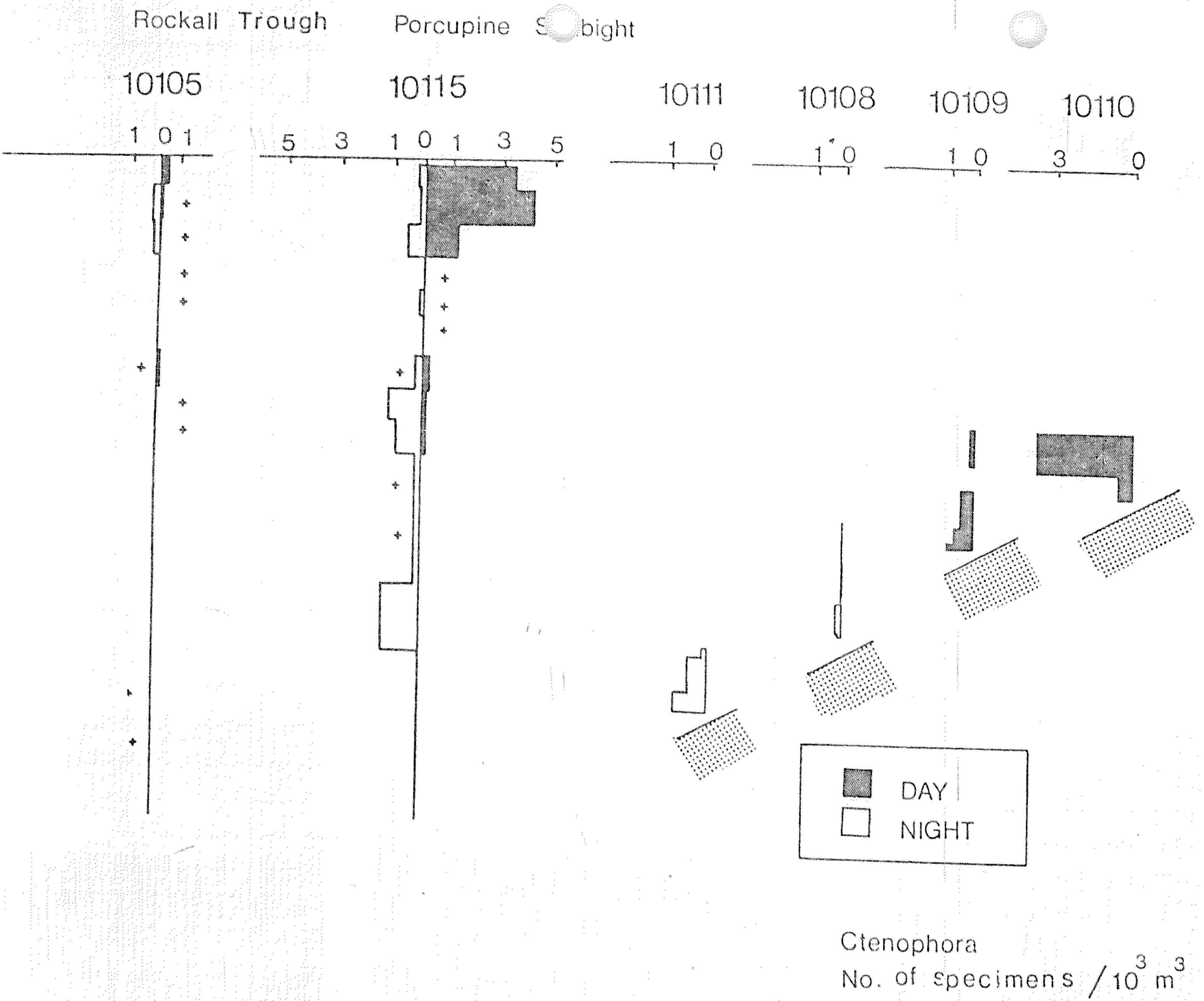


Fig. 20. Profiles of numerical abundance (Nos./1000m^3) of Ctenophora in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

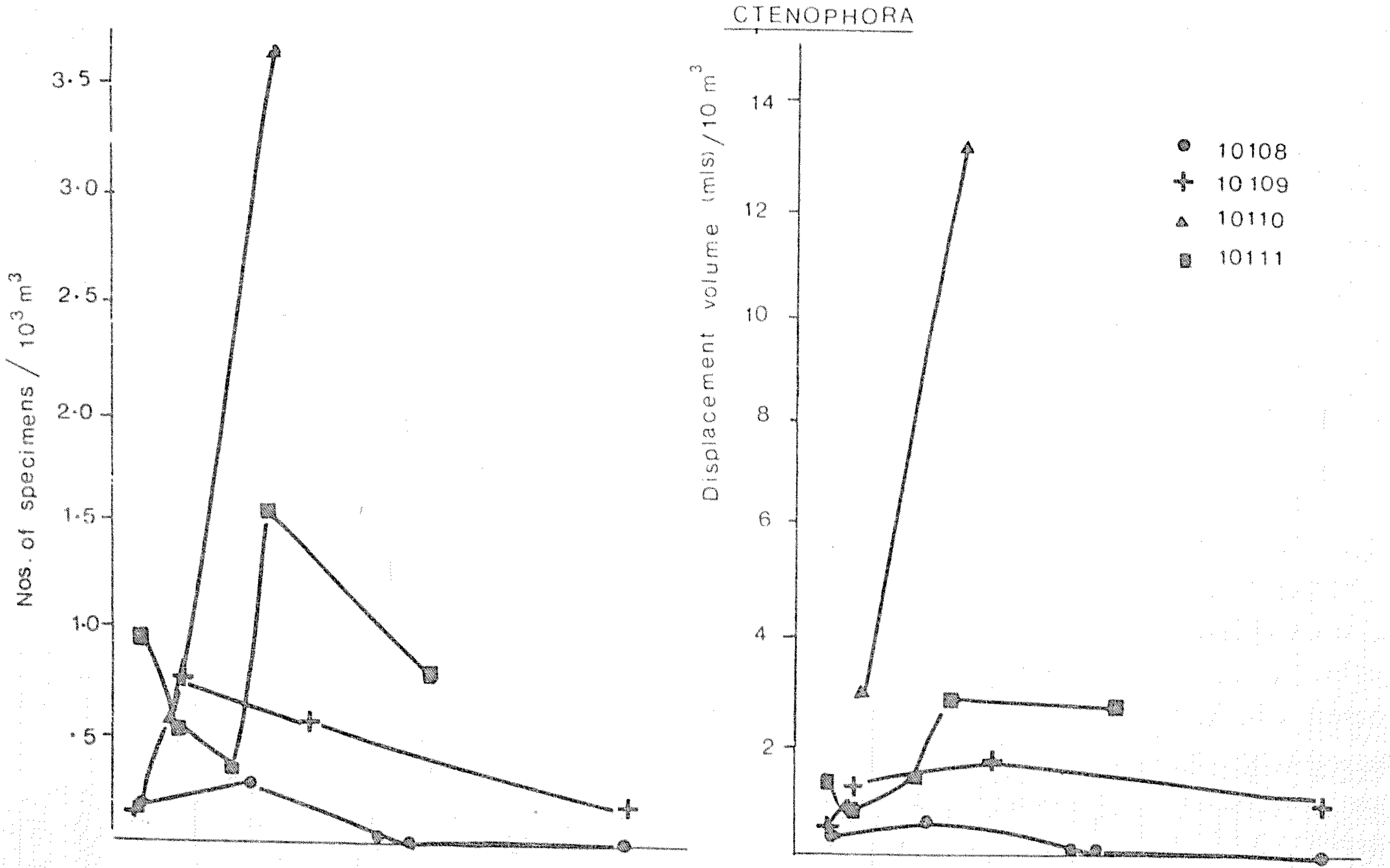


Fig. 21. Ctenophora at slope stations: A. Numerical abundance and B. biomass concentrations, plotted against average distance in metres above the bottom (RMT 8M).

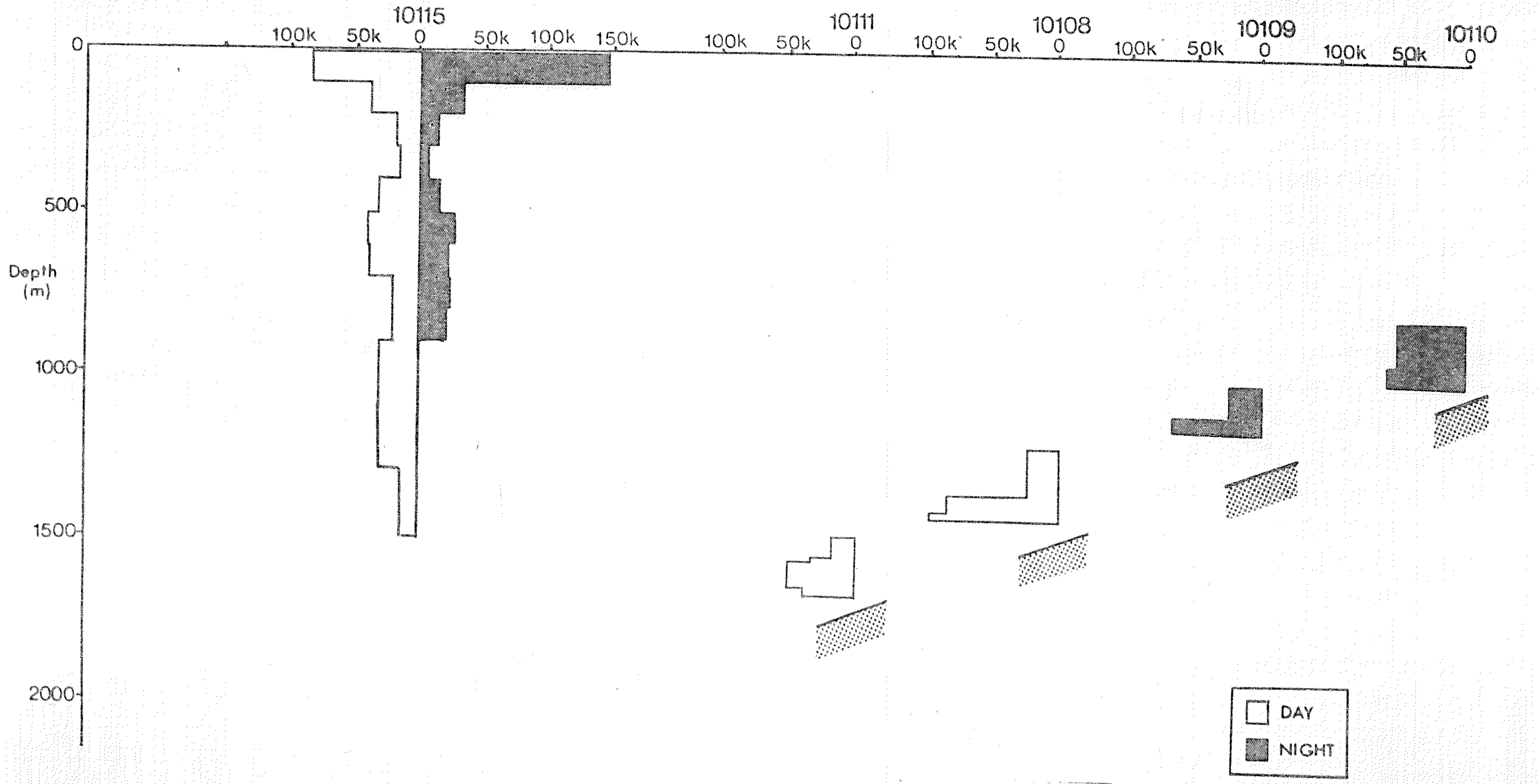


Fig. 22. Profiles of numerical abundance (Nos./1000m^3) of Copepoda in RMT 1M samples at the Seabight deep water and slope stations (see Fig. 10 for note on depths).

four slope stations the copepod concentrations increased substantially towards the sea-bed (Fig. 22). Indeed the near-bottom concentrations approached those observed in near-surface waters, especially at Station 10108 where over $100/m^3$ were caught near the bottom; this abundance was nearly 20% more than the daytime concentration in the surface 100m at the Seabight station ($\sim 83/m^3$) and five times that observed at the equivalent depth.

1.c.9 Ostracoda (Figs 23, 24)

Ostracod data are based on the RMT 1M samples. The ostracods were the second most abundant higher taxon represented in the macroplankton catches, but were an order of magnitude less abundant than the copepods. Except for the three large catches at the deep water station for which $\frac{1}{8}$ subsamples were analysed, the analyses have been based on total samples. In all over 103,000 specimens have been identified; 46 species were represented.

Total ostracod abundance profiles are shown in figure 23. At most of the slope stations ostracod densities tended to increase with increasing proximity to the sea-bed but only at Station 10108 was the near-bottom density notably higher than observed at comparable depths over deep water. At the shallowest slope station (10110) no bottom effect was observed but the densities in both hauls were greater than in equivalent samples from deep water.

A detailed analysis of the ostracod data (Ellis, in prep.) refines this picture, and shows that the individual species have different responses to proximity to the sea-bed. Of the 46 species present in the samples, 14 normally live at relatively shallow depths and were rare or absent from the slope samples, and 13 were represented only sporadically. Table 3 lists the densities of the remaining 27 species all of which normally occur at depths equivalent to those sampled in the near-bottom hauls. Fig. 24 shows how the order of abundance of the ten commonest species varied in each of the hauls from below 700m both at the deep water station and in the near-bottom samples. Comparison between the day and night hauls from 700-800m and 800-900m at the deep water station, which can be regarded as replicate hauls because diel vertical migration will have had a relatively minor effect at these depths, can be used to judge the sampling variation in rank order of abundance.

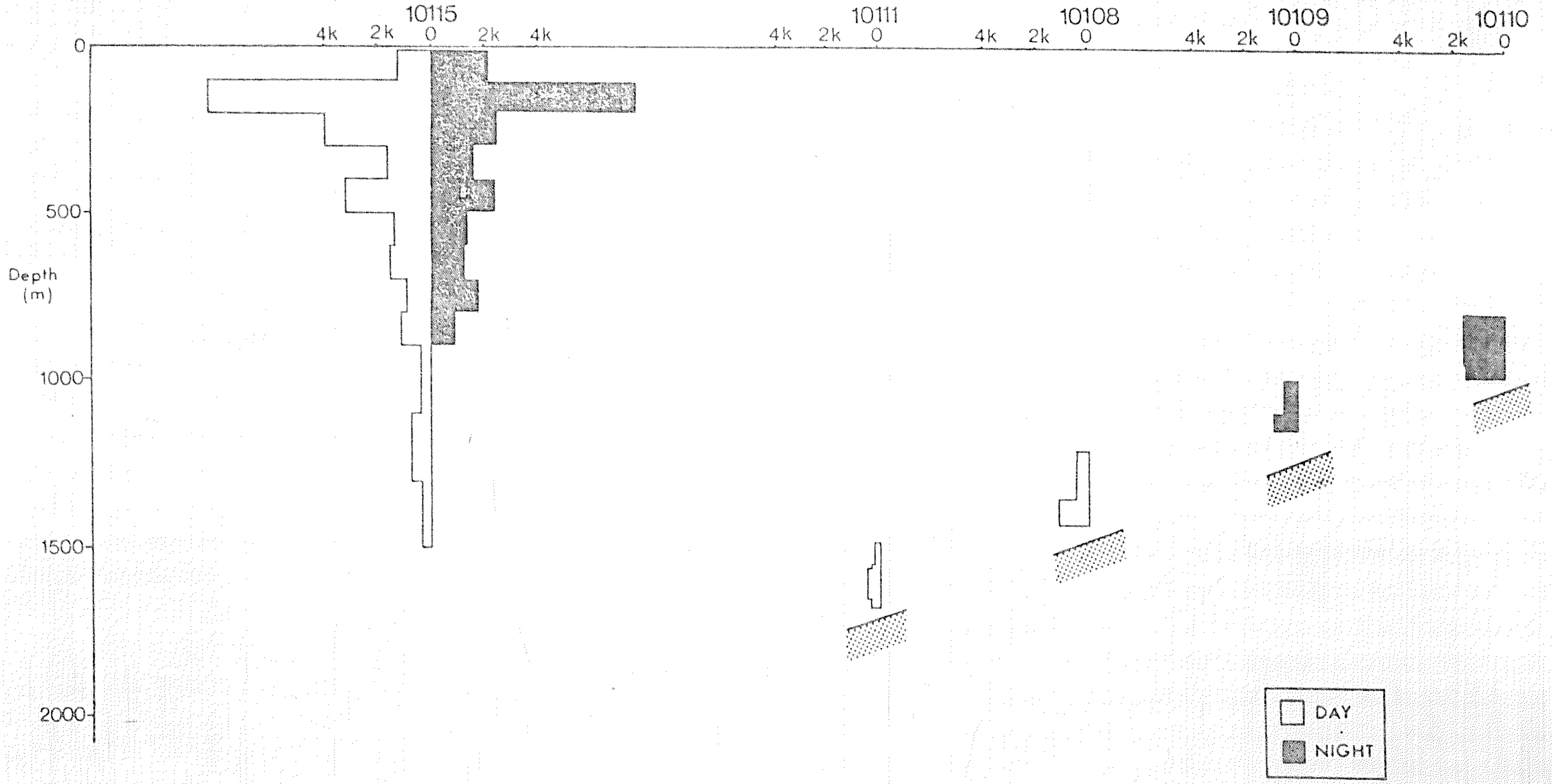
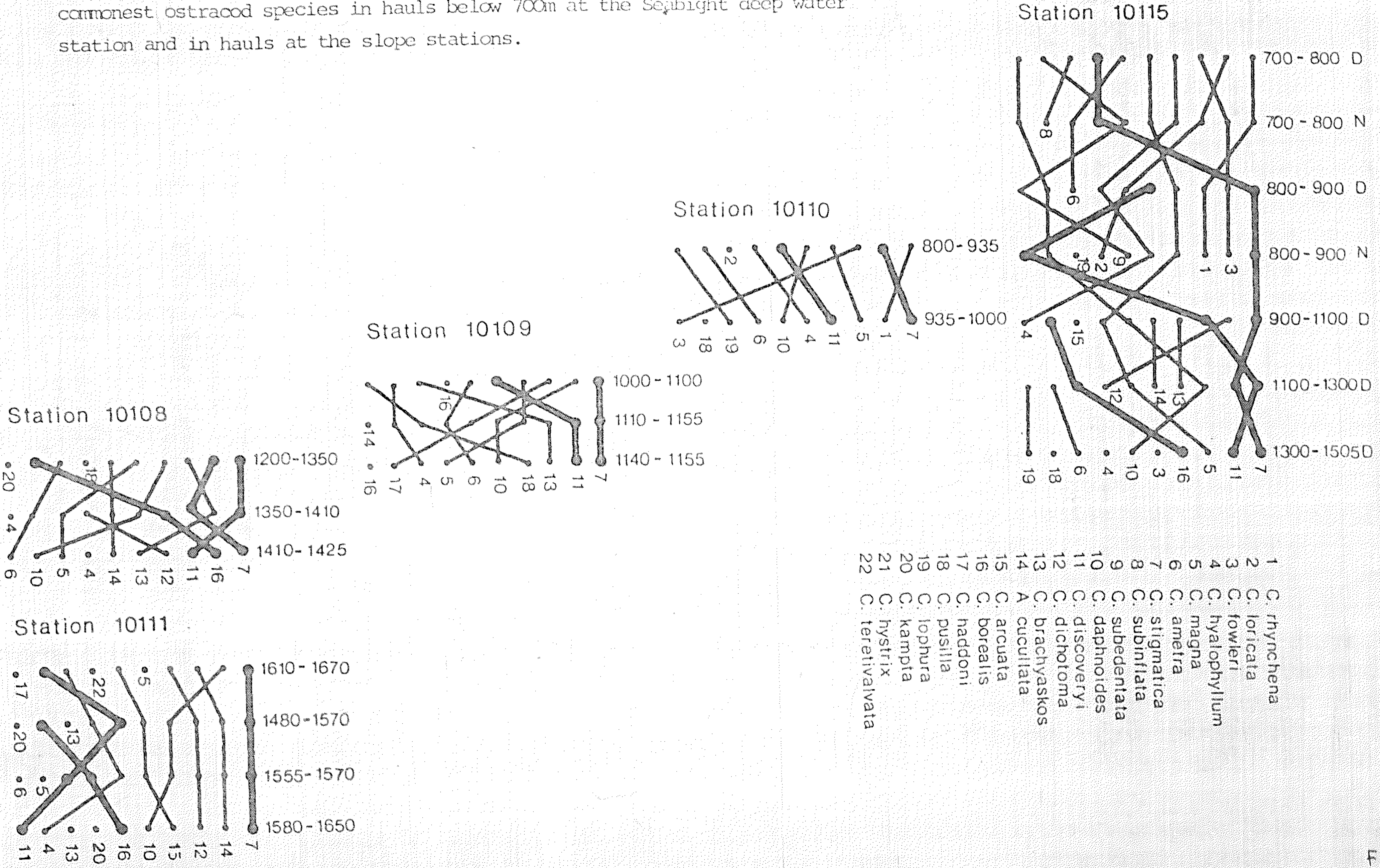


Fig. 23. Profiles of numerical abundance (Nos./1000m^3) of Ostracoda in the RMT 1M samples at the Seabight deep water and slope stations (see Fig. 10 for note on depths).

Fig. 24. Diagram illustrating the changes in rank order of abundance of the ten commonest ostracod species in hauls below 700m at the Seabight deep water station and in hauls at the slope stations.



In figure 24 three species have been picked out to emphasise how their relative abundances changed. C. stigmatica (species #7 in the figure) was the dominant species at nearly all depths >800m over deep water, and also over the slope. However, the species that was codominant with it below 900m at the deep water station, C. discoveryi (#11) was only codominant at 1100-1425m over the slope. C. borealis (#16) was increasingly important from 900m down at the deep water station, but was only codominant close to the sea floor at one of the slope stations (10108). In general, the order of species abundance changed, relatively little towards the sea floor at the shallow slope station (10110), quite sharply at the middle two slope stations (10109, 10108), and hardly at all between the four dominant species at the deepest station, but quite substantially between the lesser abundant species.

From Table 3 it can be seen that many species were more abundant over the slope than at comparable depths over deep water, e.g. C. rhynchena and C. brachyaskos. In contrast two species C. subedentata and C. obtusata showed reductions in abundance over the slope. Another effect was the displacement of the depth ranges of some species over the slope. C. pusilla occurred shallower than expected, whereas A. cucullata, C. dichtoma and C. arcuata occurred deeper.

Two species are of particular interest:
C. dorsotuberculata was uncommon in the catches, only six specimens (three juveniles and three adult females) were taken. However, this species was caught only in the slope stations. Examination of 'Discovery' collection records for ostracods, held in the IOS database (Domanski, 1981) shows that this species has previously not been recorded north of 42°N. It is possible that this bathypelagic species is seasonal in its occurrence but its absence in the Seabight suggests that more likely its presence over the slope may result from its advection into the region in a slope current.

C. hystrix was found for the first time in these hauls (Angel and Ellis, 1981). It is probably a member of the suprabenthic community. Its gut contents, which included mineral particles as well as bacteria and unidentifiable material, suggested that the species may feed on the sea-bed. Twenty-four of the 26 specimens of C. hystrix taken, were caught in hauls within 30m of the sea floor. The majority were taken at station 10108. This species was the only ostracod which seemed to be associated with the benthopelagic environment. At 4000m off

Table 3. Densities of some ostracod species for hauls below 700m over the slope and at the Porcupine Seabight deep water station

Species	Deep Water Numbers/1000m^3							Slope											
Station	10115							10111				10108			10109			10110	
Sample depth (m)	700-800D	800-900N	700-800N	800-900N	900-1100D	1100-1300	1300-1500	1480-1570	1555-1750	1580-1650	1610-1670	1210-1350	1350-1410	1410-1425	1000-1100	1110-1155	1140-1155	800-950	935-1000
C. ametra	26	37	43	20	1	12	7	1	2	1	1	11	25	12	25	58	43	37	74
C. arcuata	-	-	-	-	16	+	-	19	27	29	17	1	8	2	-	-	-	-	-
C. borealis	7	25	34	3	9	31	21	3	7	21	1	9	97	240	14	10	15	6	14
C. brachyaskos	-	-	-	-	42	59	4	4	1	5	1	67	220	74	9	102	91	4	25
C. daphnoides	13	34	30	28	28	64	15	19	33	21	50	53	82	18	81	61	55	136	84
C. dichotoma	-	-	-	-	80	35	1	26	36	70	24	3	34	100	-	-	-	-	-
C. discoveryi	-	65	-	26	56	242	86	18	6	4	3	156	393	175	54	205	218	109	155
C. dorsotuberculata	-	-	-	-	-	-	-	-	+	+	-	-	1	-	-	-	+	-	1
C. elegans	12	9	27	18	+	1	1	-	-	1	-	1	2	1	1	4	4	8	3
C. fowleri	101	212	351	194	-	+	16	-	+	-	1	+	-	-	67	60	18	195	38
C. haddoni	3	2	3	1	1	1	1	2	2	1	2	2	3	5	2	1	-	1	4
C. hyalophyllum	41	61	73	60	4	4	8	7	9	4	5	5	10	2	9	26	25	66	92
C. hystrix	-	-	-	-	+	-	-	-	-	+	-	-	1	18	-	-	-	-	1
C. imbricata	7	3	12	2	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-
C. kampta	-	1	-	2	1	3	1	3	2	6	1	6	7	8	4	19	5	10	6
C. lophura	8	15	25	29	1	7	5	+	+	-	-	3	1	2	6	23	13	22	47
C. loricata	113	63	182	34	+	1	2	+	+	-	-	1	-	-	6	6	3	61	14
C. macroprocera	-	1	+	1	1	-	+	-	-	-	-	-	-	1	-	-	-	-	1
C. magna	27	68	68	76	16	54	30	7	4	1	19	30	31	18	62	83	28	179	162
C. obtusata	9	12	29	13	1	1	3	-	-	-	-	-	1	2	1	+	1	1	2
C. pusilla	-	1	-	1	-	4	7	-	-	-	-	20	4	-	9	45	81	10	46
C. rhynchena	394	122	679	87	-	-	1	-	-	-	1	-	-	1	9	1	2	465	169
C. spinifera	90	15	17	10	-	-	1	-	-	-	-	-	-	-	+	-	-	19	3
C. stigmatica	25	256	59	237	98	137	134	73	162	257	110	73	119	353	198	251	234	315	650
C. subedentata	18	30	63	38	+	2	+	1	+	1	-	-	+	2	-	+	-	9	1
C. teretivalvata	3	5	7	8	1	1	2	2	1	-	10	1	3	6	1	1	2	1	3
A. cucullata	1	-	-	+	37	57	1	32	57	71	45	20	55	56	3	14	9	-	-

the Northwest African coast similar near-bottom hauls contained an endemic community of 25 species all of which are new to science (Discovery unpublished data). Thus there may be an important distinction between the abyssal near sea-bed communities which have no species in common with pelagic communities, and the slope communities which are essentially modified midwater communities.

1.c.10 Amphipoda (Fig. 25)

The data for these crustaceans are derived from the RMT 1M samples. Their abundances were relatively low reaching a maximum of only $21/1000m^3$. At all four slope stations their density increased towards the bottom. At the deeper two slope stations (10111 and 10108) densities were higher than at comparable depths over deep water but slightly lower at the other two stations. Many amphipods are commensal or parasitic at some stage of their life histories with gelatinous plankton, so their densities here probably relate to the distribution patterns of siphonophores, ctenophores and medusae. Specific analysis may show that some of the species responsible for the near-bottom increase in amphipod density may be associated with benthic coelenterates.

1.c.11 Decapoda (Figs 26, 27, 28, 29)

In the Rockall Trough maximum numbers occurred by day at 500-900m (>6 specimens/$1000m^3$) (Fig. 26) with a secondary maximum at 1500-1700m. At night large numbers of juvenile Decapoda (mainly Sergestes) occurred in the top 100m, the result of diel migration. At the Seabight station decapods occurred mainly below 500m with a maximum of 10-11 specimens/$1000m^3$ at 700-900m. At night about 4 specimens/$1000m^3$ occurred in the surface 100m, and then deeper down there was a gradual decrease in concentration to about 500m below which there was a steady increase to 6 specimens/$1000m^3$ at 800-900m.

Over the slope most of the hauls from well above the sea floor contained decapods in numbers similar to those at comparable depths at the deep water stations. However, relatively high concentrations of decapods occurred in some of the hauls close to the sea-bed particularly at stations 10108 and 10109 (Fig. 27). Generally at both deep water stations at depths above 900m biomass profiles were similar to those for concentration. Below 900m biomass concentrations were erratic but there was a tendency for biomass to increase

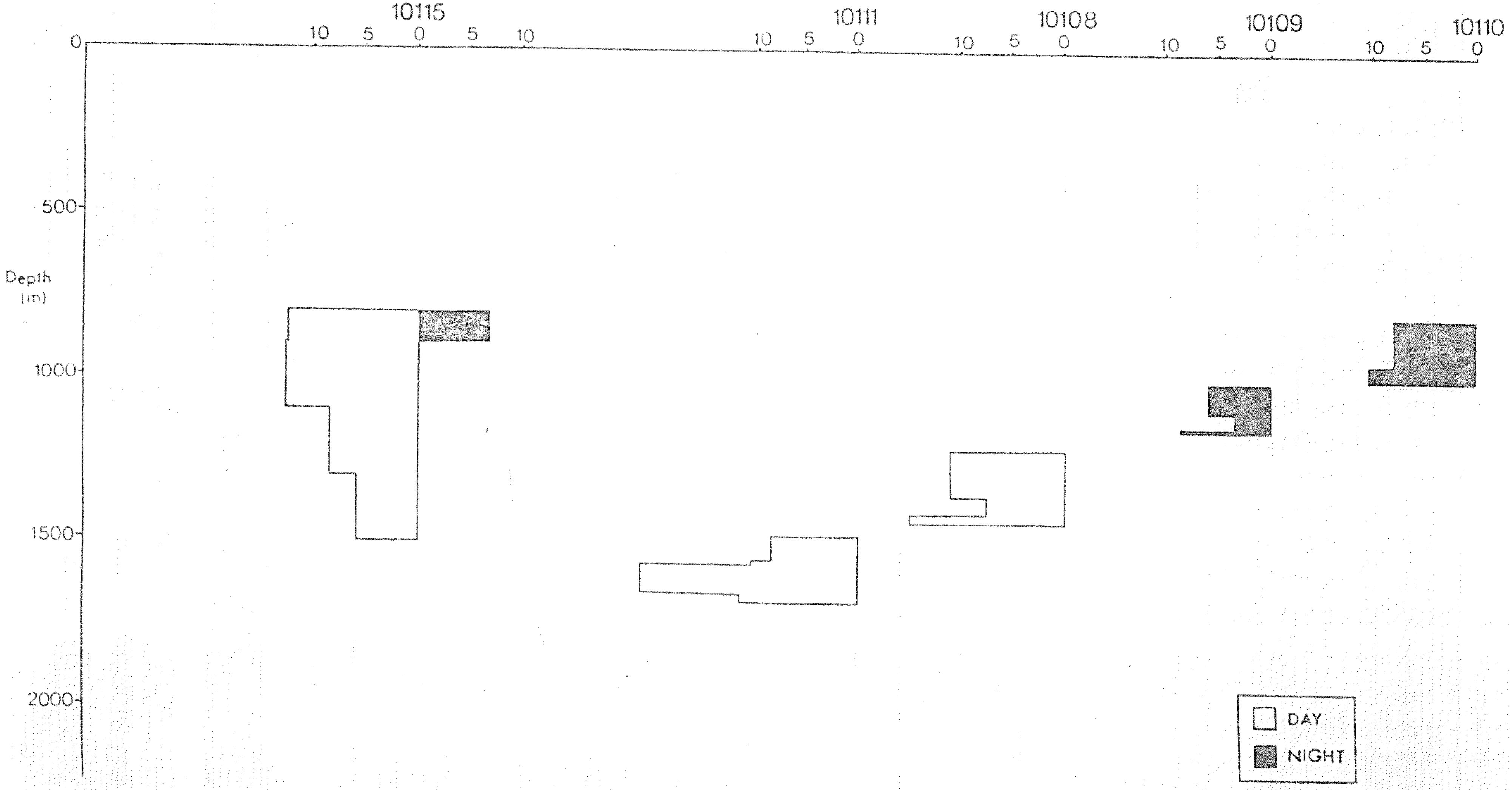


Fig. 25. Profiles of numerical abundance (Nos./$1000m^3$) of Amphipoda in RMT 1M samples at the deep water and slope stations (see Fig. 10 for note on depths).

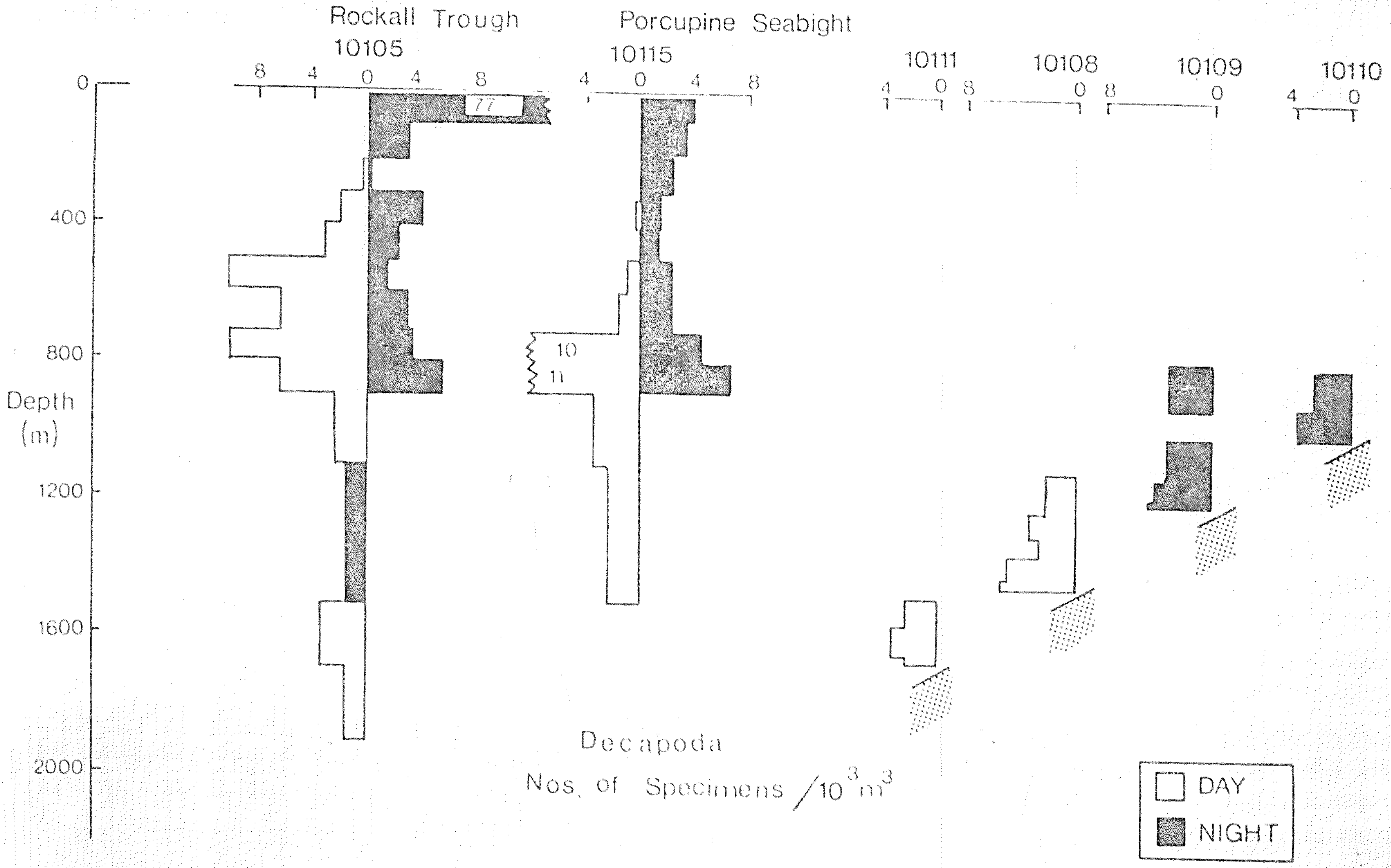


Fig. 26. Profiles of numerical abundance (Nos./1000m^3) of Decapoda in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

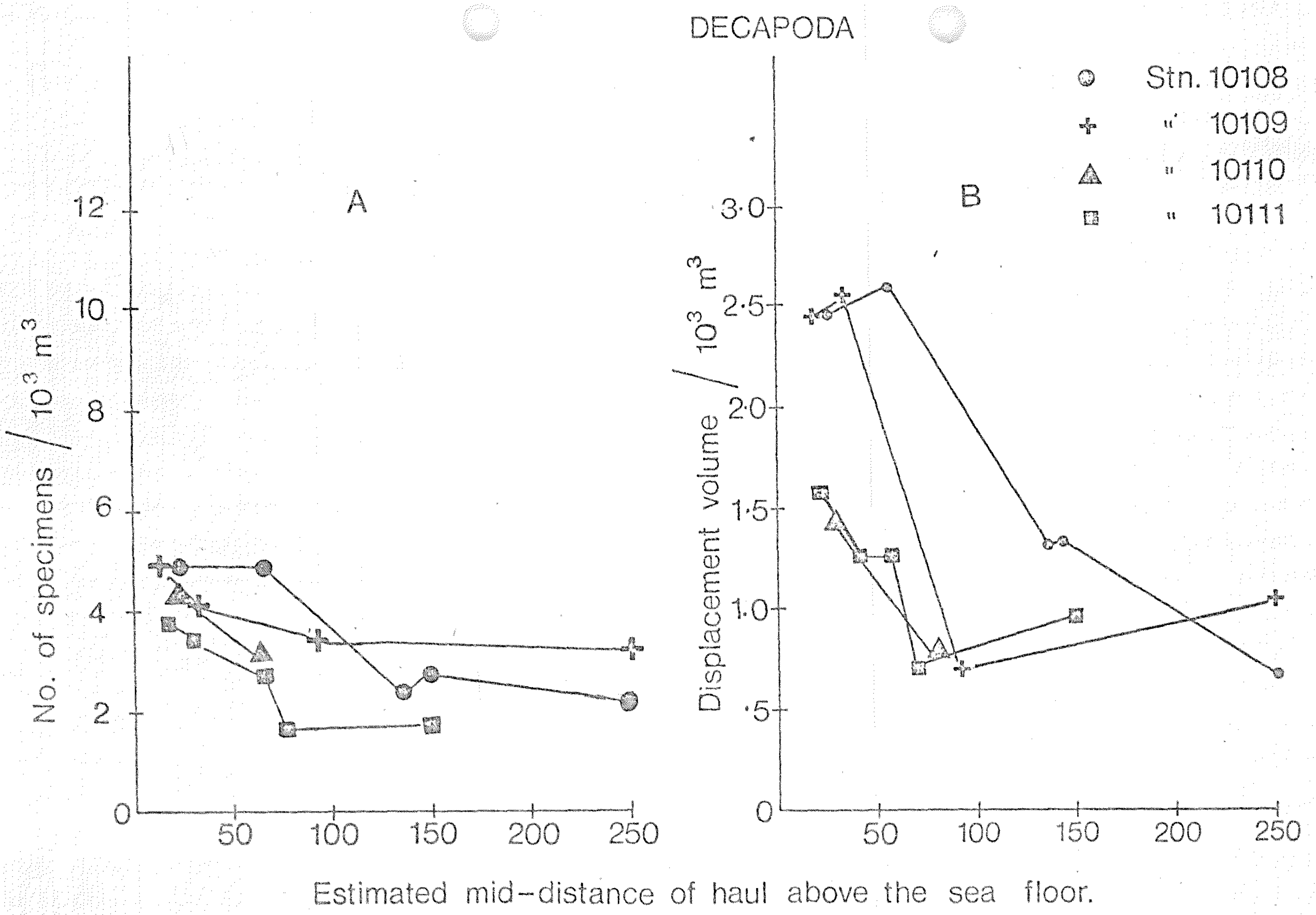


Fig. 27. Decapoda at slope stations: A. Numerical abundance and B. biomass concentration plotted against average distance of the haul in metres above the bottom (RMT 8M).

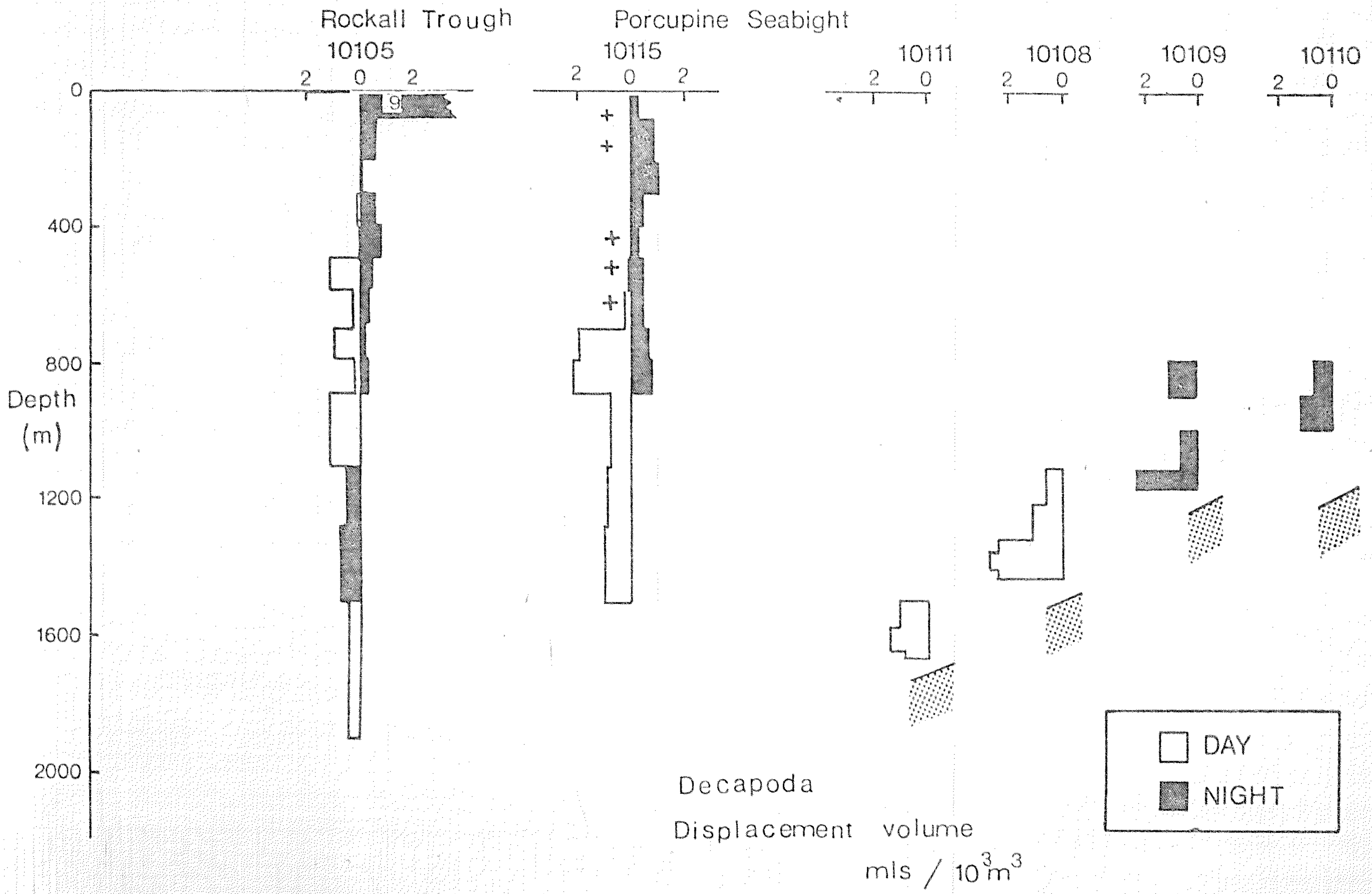
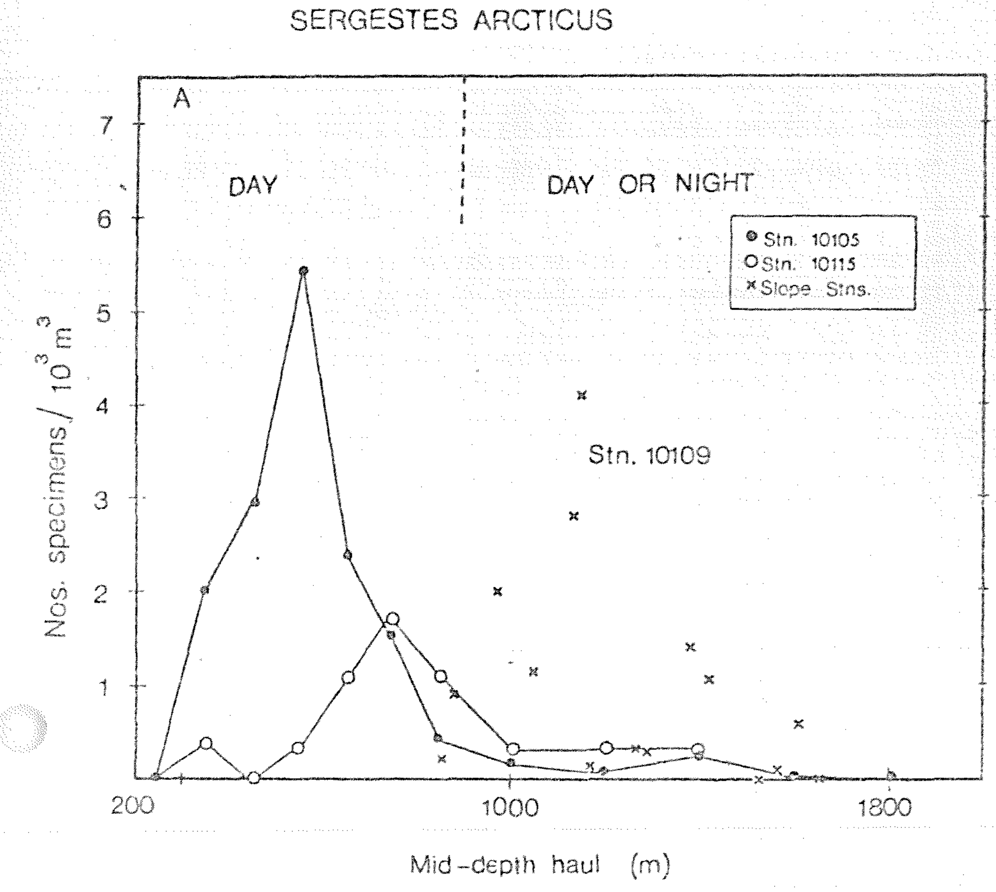


Fig. 28. Profiles of biomass (displacement volume mℓs/1000m^3) of Decapoda in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).



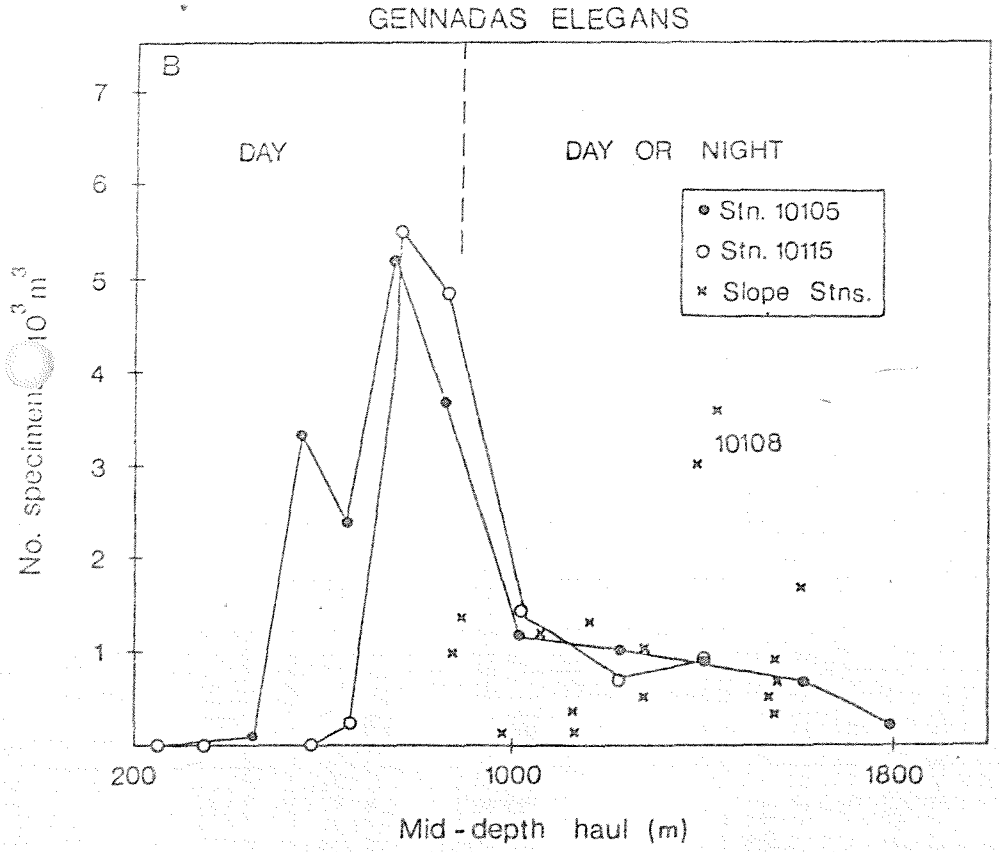


Fig. 29. A. Numerical abundance Nos./$1000m^3$ of Sergestes arcticus in RMT 8M samples at the deep water and slope stations plotted against average sampling depths in metres.
B. As above for Gennadas elegans.

relative to numerical abundance, i.e. specimens tended to be larger, in the deeper layers (Fig. 28). Over the slope there was generally an increase in biomass with increased proximity to the sea floor (Fig. 27).

There were four dominant species throughout the survey area Sergestes arcticus, Sergia species (robustus group), Gennadas elegans and Hymenodora gracilis. S. arcticus is a strong diel migrant occurring in the Rockall Trough and the Seabight deep water stations at 200-1000m during the day (up to 6 specimens/1000m^3 at 500-600m in the Rockall Trough). At night 72 and 3 specimens/1000m^3 occurred in the surface 100m in the Rockall Trough and Seabight respectively. Relatively few specimens were found below 1000m. Over the slope this species occurred in similar concentrations well above the bottom, but in much higher concentrations close to the sea-bed. This increase was particularly noticeable at Station 10109 when the sounding was around 1200m (Fig. 29A). Thus over the slope the vertical distribution of this species extended deeper than at the deep water stations. By day at the deep water stations G. elegans was found predominantly at 500-1000m and 700-1100m respectively with maximum concentrations of about 6 specimens/1000m^3 at 700-800m. There was limited diel migration of part of the population towards the surface at night. Over the slope most samples contained similar concentrations to those in deep water. However, exceptionally large concentrations occurred in near-bottom hauls at Station 10108 (Fig. 29B).

In contrast to the Sergestes and Gennadas species, H. gracilis did not occur at the two shallowest slope stations (10109 and 10110), but was found in relatively low concentrations at Station 10108 and in higher concentrations at the deepest slope station (10111). Its distribution over the slope was similar to that in deep water.

The data for the decapods will be described in detail in a separate publication (Hargreaves, in press).

1.c.12 Mysidacea (Figs 30, 31, 32, 33)

The distributions of oceanic pelagic mysids in the Atlantic have been reviewed by Mauchline and Murano (1977). Most of the species recorded in this survey were described by Tattersall (1955). At both deep water stations they mainly occurred below 600m but the depths of the maximum concentrations

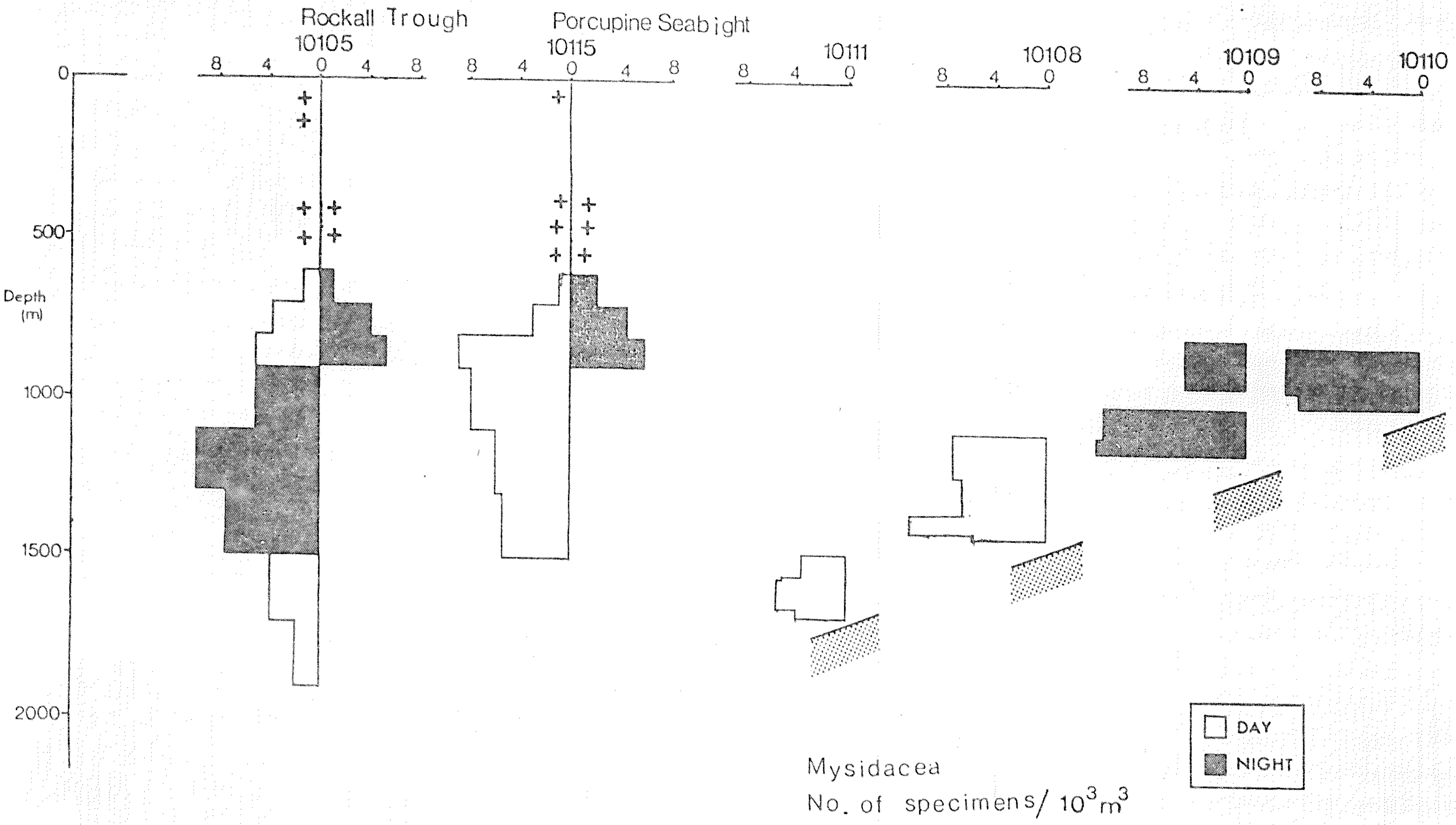


Fig. 30. Profiles of numerical abundance (Nos./$1000m^3$) of Mysidacea in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

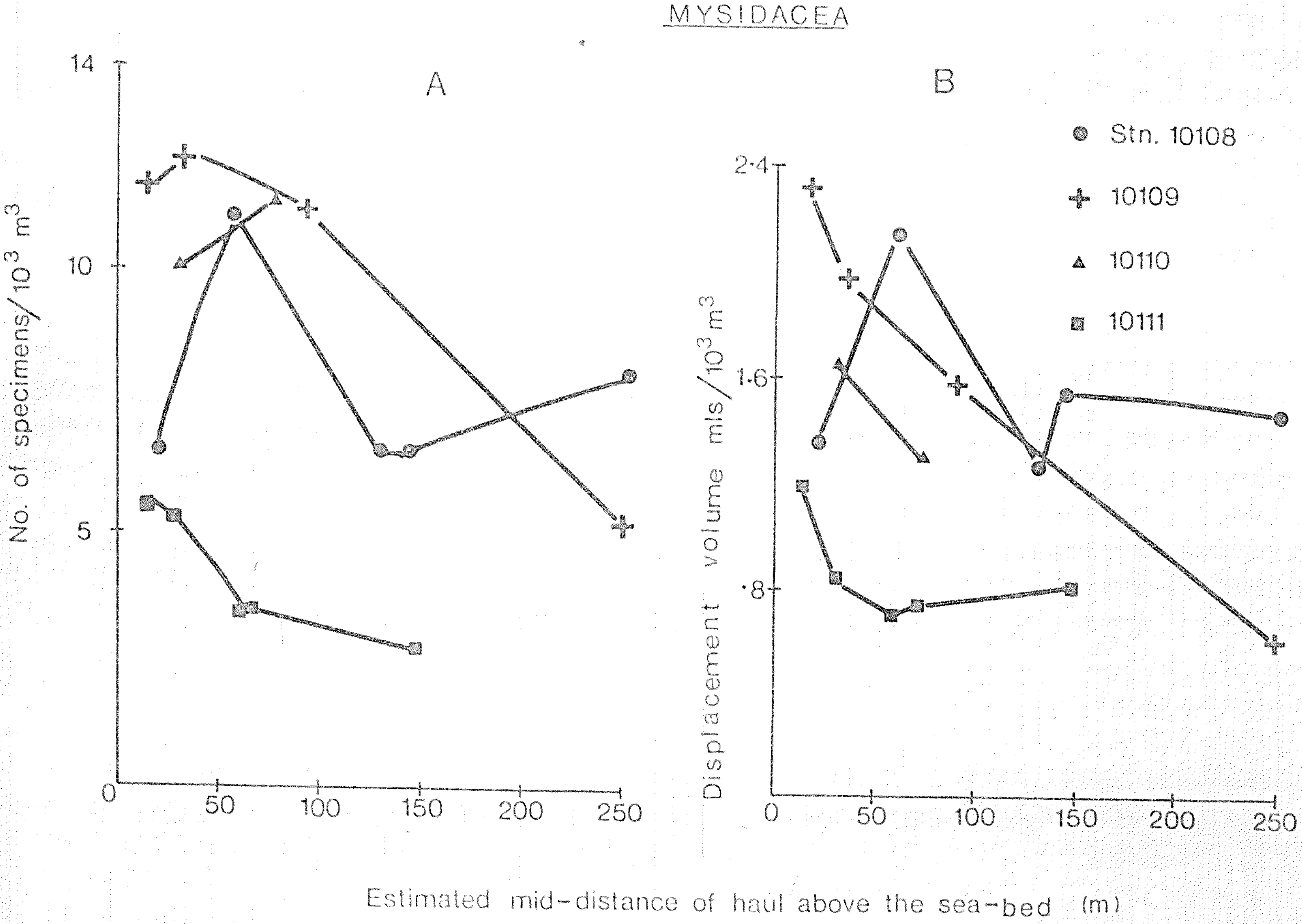


Fig. 31. Mysidacea at slope stations: A. Numerical abundance and B. biomass concentration plotted against average distance in metres above the bottom (RMT 8M).

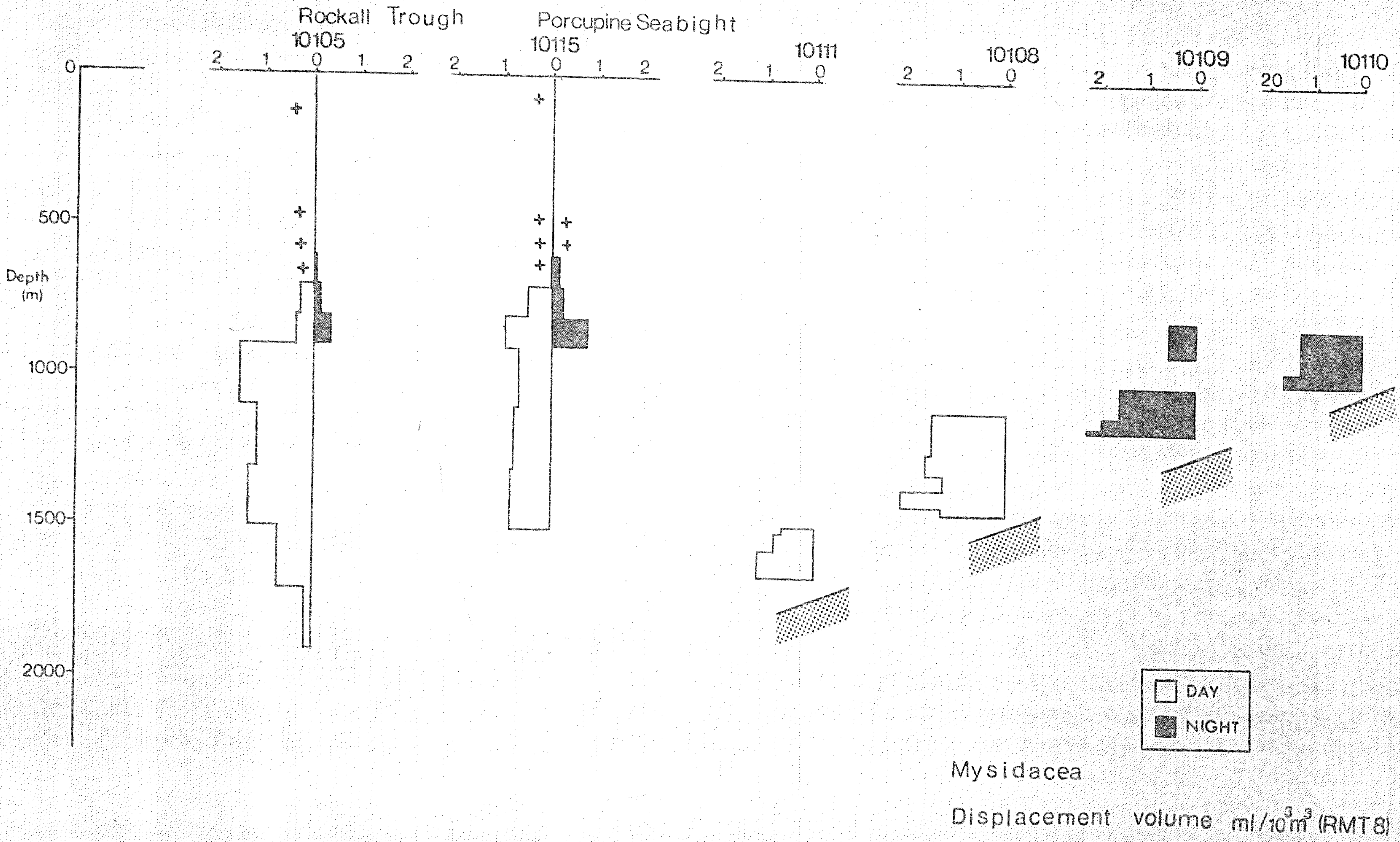


Fig. 32. Profiles of biomass (displacement volume mℓs/1000m^3) of Mysidacea in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

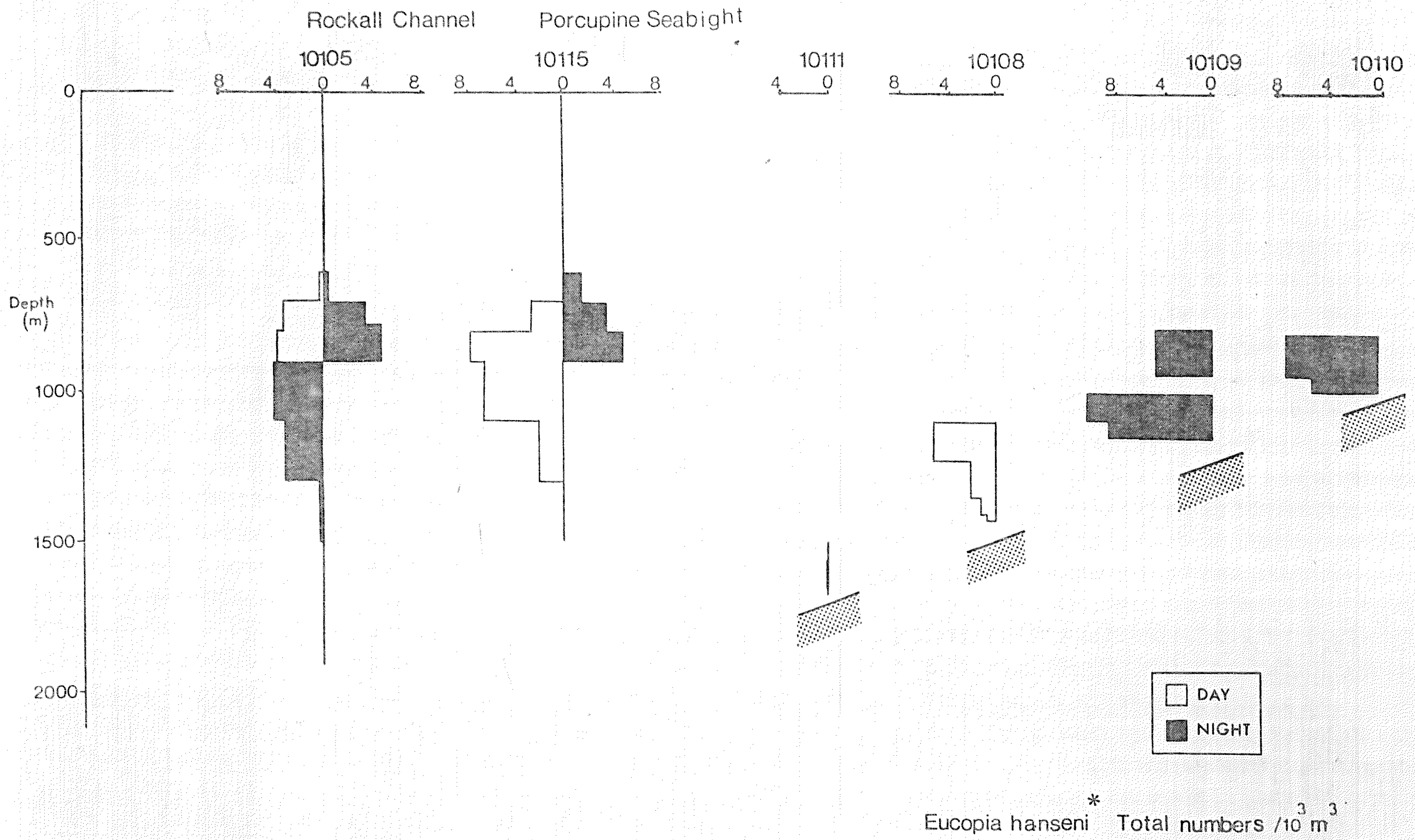


Fig. 33. Profiles of numerical abundance (Nos./1000m^3) of Eucopia hanseni in RMT 8M samples in the deep water and slope stations (see Fig. 10 for note on depths) *E. hanseni is considered to be synonymous with Eucopia unguiculata.

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differed between the two stations; in the Rockall Trough maximum concentrations of approximately 8 specimens/1000m^3 occurred at 1100-1500m, whereas at the Seabight station similar concentrations occurred at 800-1100m (Fig. 30).

Over the slope at Station 10110 abundances were slightly greater than those at similar depths at the Seabight station but decreased slightly close to the bottom (Fig. 31). At Station 10109 concentrations were low at the shallowest haul but increased to >10 specimens/1000m^3 closer to the sea-bed. At Station 10108 the concentrations (6-8 specimens/1000m^3) were generally similar to those observed at comparable depths over deep water, but in one haul there were >10 specimens/1000m^3. At the deepest slope station (10111) concentrations were relatively low (< 4 specimens/1000m^3) but slightly increased close to the bottom.

Biomass profiles were similar to numerical abundance profiles at the Seabight station, but at the Rockall station there were some differences in that there was a decrease in biomass relative to concentration at 700-900m and at 1100-1300m (Fig. 32) resulting from the presence of large numbers of small immature specimens. Biomass profiles over the slope were similar to the concentration profiles, except in the haul closest to the sea floor at Station 10110, where there was an increase in biomass relative to abundance. Two species of mysid formed the bulk of the mysid populations, *Eucopia hanseni* and *Eucopia grimaldii*. The distribution of *E. hanseni* is given in Fig. 33. At both deep water stations this species comprised nearly the whole of the mysid catch above 1100m. Below 1500m in the Rockall Trough *E. grimaldii* was dominant while at 1100-1500m both species were present. The distribution of these two species over the slope reflected their vertical distribution in midwater over deep water. *E. hanseni* was found in relatively large numbers in the shallow near-bottom hauls at stations 10109-10110; at Station 10110 despite the decrease in concentration close to the sea-bed, the values were still within the range observed at similar depths at the deep water stations. At Station 10109 there appeared to be a peak in concentrations at just about the deepest sampling depth. Further down the slope at Station 10108 concentrations were similar or slightly greater to those at the deep water stations, but again tended to decrease towards the bottom. Hardly any specimens were found at the deepest station (10111).

Over the slope the distribution of *E. grimaldii* was quite unlike that of *E. hanseni*. Concentrations of *E. grimaldii* were extremely low at the shallower slope stations 10109-10110, but further down the slope at Station 10108 most observed values were lower than at similar depths over deep water; the notable exception occurred about 60m above the bottom where values were similar to those at the deep water stations. At Station 10111 haul values were similar to those at the deep water stations.

1.c.13 Euphausiacea (Figs 34, 35, 36, 37, 38)

In the Rockall Trough in daytime euphausiids were found mainly from 200-600m at maximum concentrations of 31 specimens/1000m^3 at 300-400m (Fig. 34). At night very large numbers occurred in the surface 200m (116 and 58 specimens/1000m^3 respectively in the 0-100m and 100-200m hauls). Below 600m abundances were low both by day and night, but there was a small maximum at 800-900m. At the Seabight station euphausiid vertical distribution was similar to that in the Rockall Trough but in general abundances were greater. By day maximum concentrations of 49-59 specimens/1000m^3 occurred at 300-500m; by night the maximum moved up into the surface 300m; 254 specimens/1000m^3 occurred at 10-100m. At both deep water stations above 900m biomass profiles were similar to those for numerical abundance. However, below 900m in the Seabight there were small but erratic increases in biomass relative to concentration (Fig. 35). Abundances in many of the near-bottom hauls at the slope stations were comparable to those at similar depths at the deep water stations (Figs 34 and 36). In the haul closest to the sea floor at Station 10110 there was a two-fold increase in numerical abundance and biomass. At Station 10109 there was again a slight increase close to the sea-bed but values were relatively low. At Station 10108 high abundances occurred in some hauls farthest from the bottom; at Station 10111 values were consistent with those at the deep water stations.

Presence of some of the specimens of euphausiids in deep hauls probably resulted from contamination. Small specimens can pass through the meshes when the net is closed and slight leakage can occur between the closed bars of the net particularly when the net is plunging at the surface during recovery. The known vertical ranges of the species were used to judge which were probable contaminants. Only three of the euphausiid species are well-known as inhabitants of relatively deep water, Bentheuphausia amblyops, Thysanopoda microphthalma and Thysanopoda acutifrons (James, personal communication; Hargreaves, in prep.). Below 500m in the Seabight B. amblyops occurred in very low concentrations (<1 specimen/1000m^3) (James, personal communication). At the shallower slope

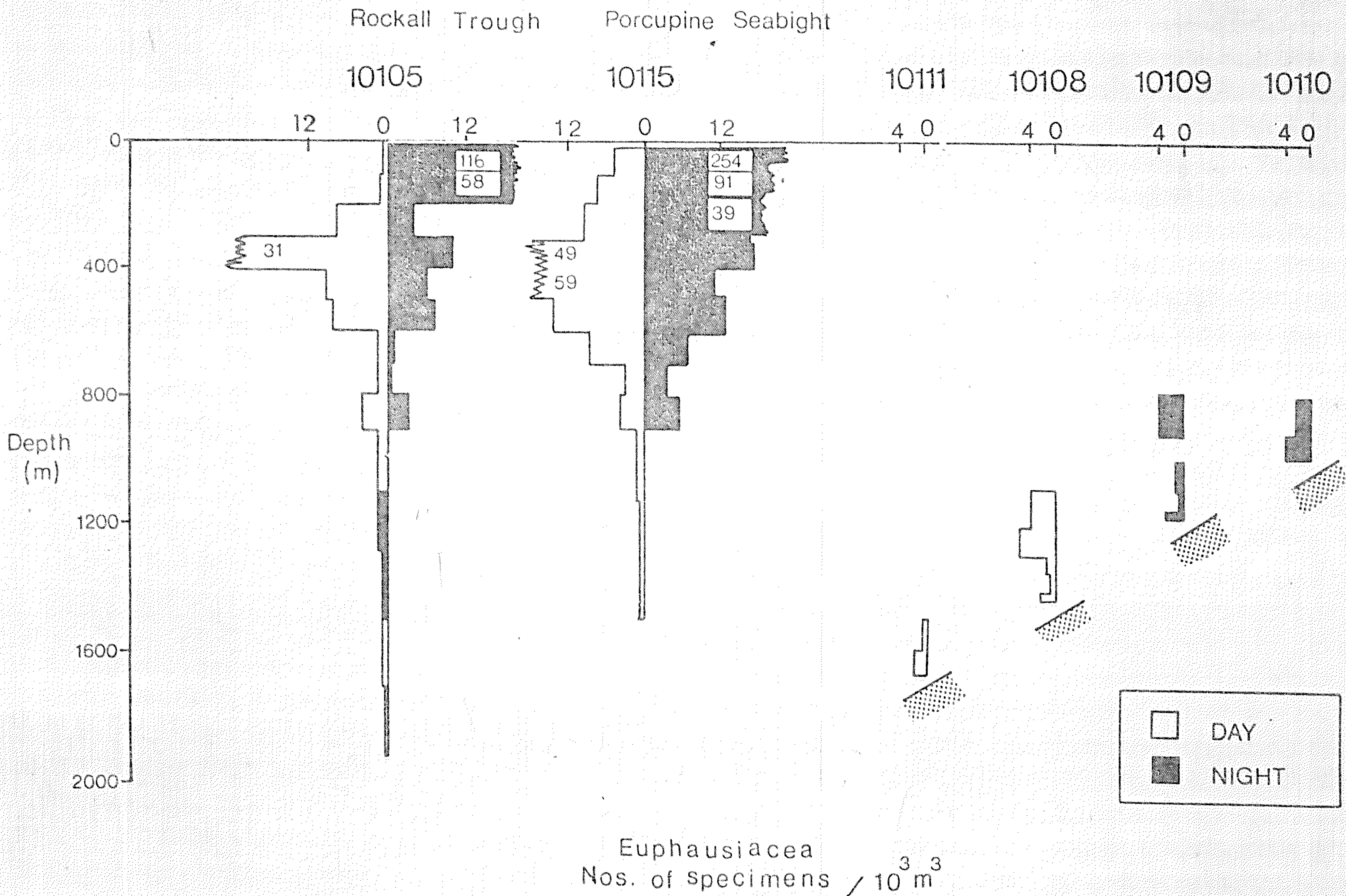

Fig. 34. Profiles of numerical abundance (Nos./$1000m^3$) of Euphausiacea in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

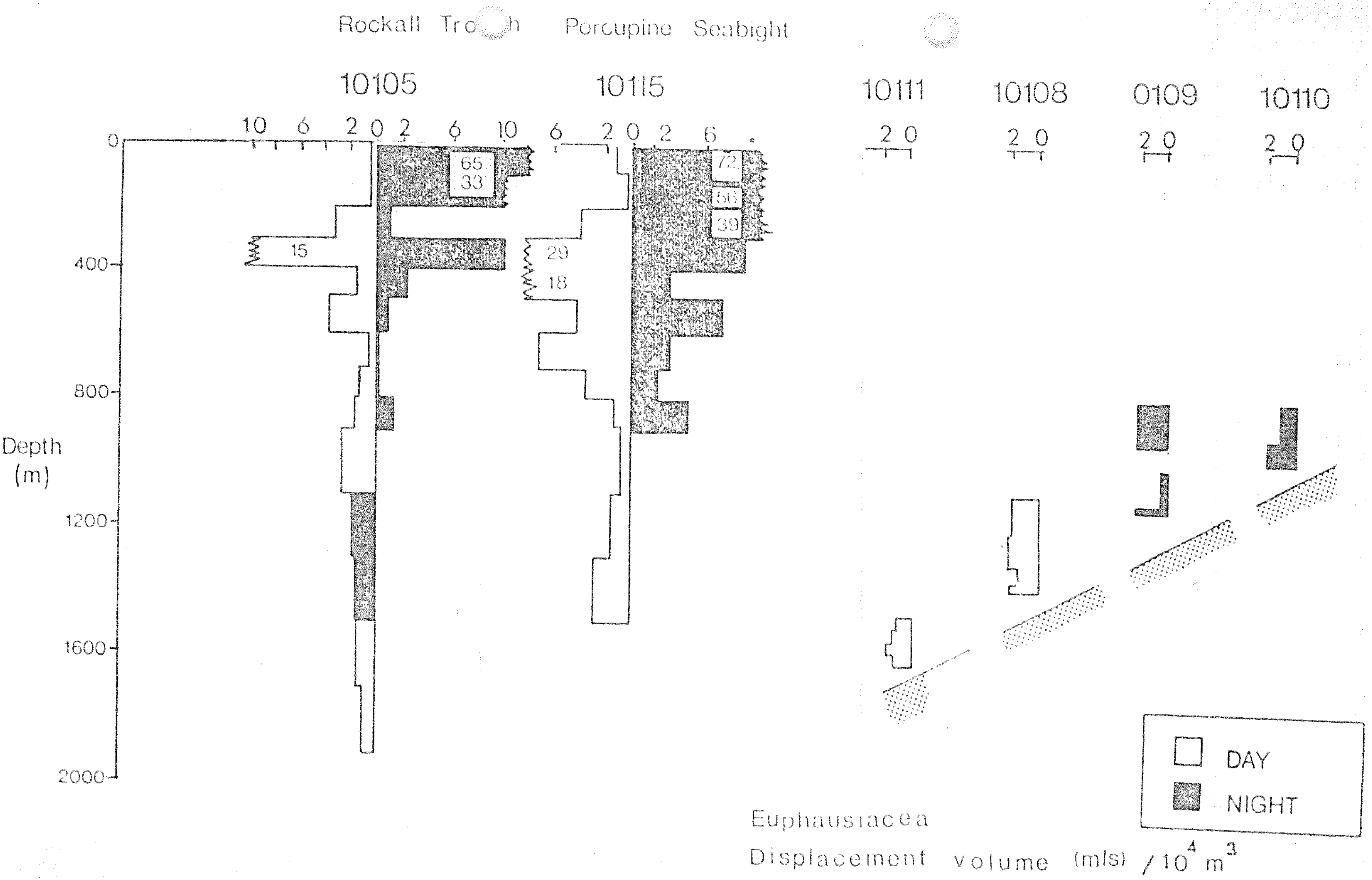

Fig. 35. Profiles of biomass (displacement volume mls/10000m^3) of Euphausiacea in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

EUPHAUSIACEA

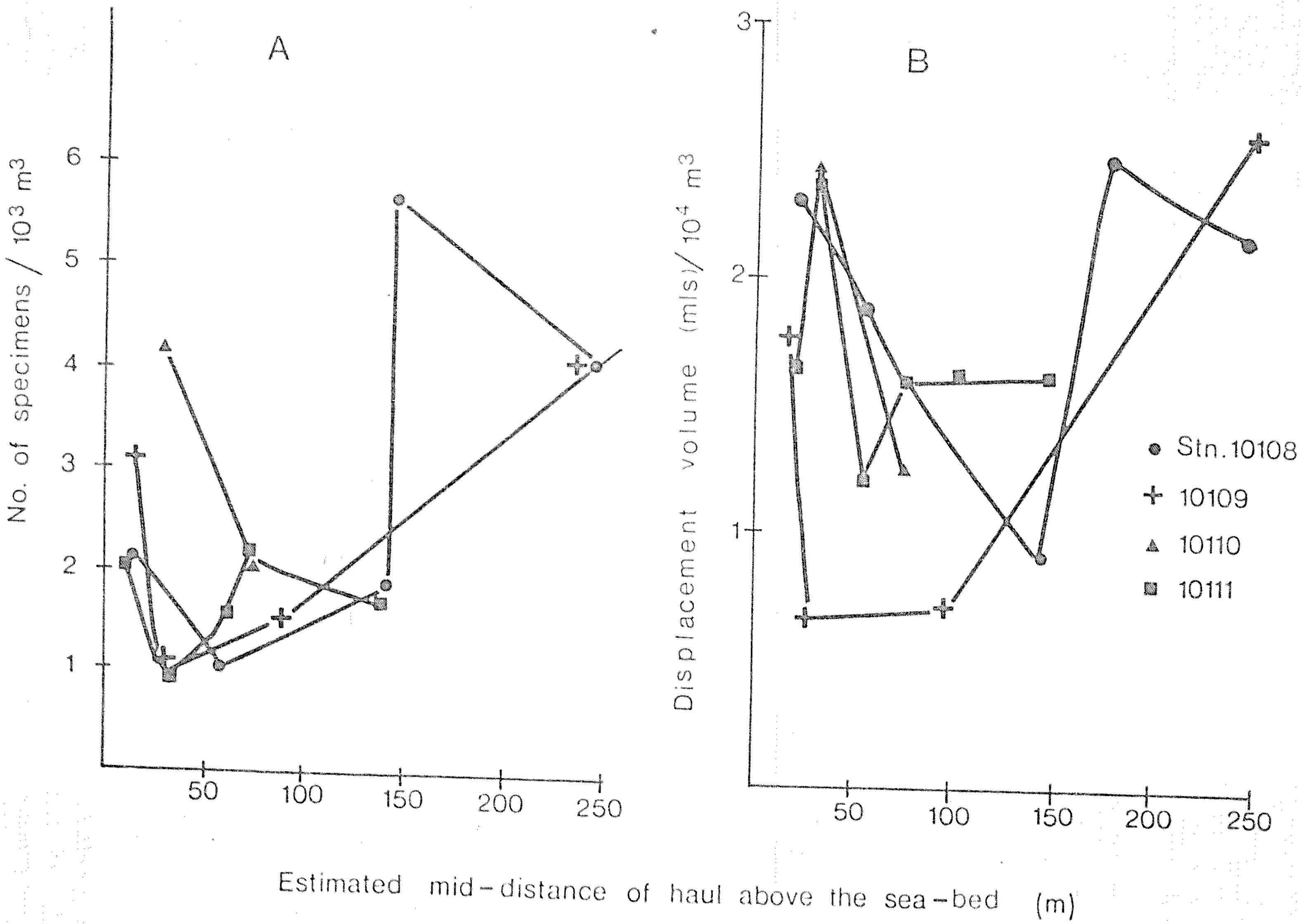

Fig. 36. Euphausiacea at slope stations: A. Numerical abundance and B. biomass concentration, plotted against average distance above the bottom in metres (RMT 8M).

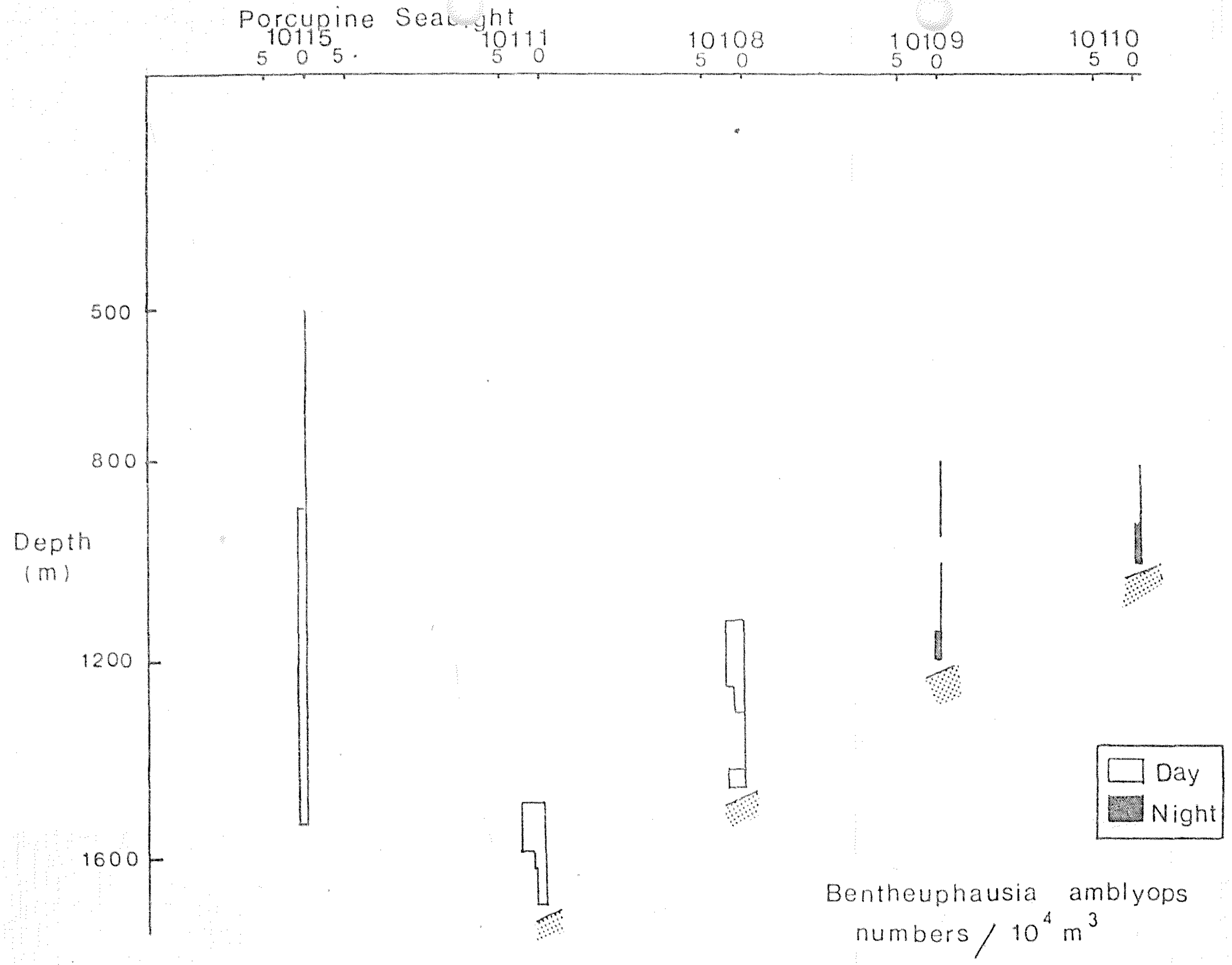

Fig. 37. Profiles (below 500m) of numerical abundance (Nos./10000m^3) of *Bentheuphausia amblyops* in RMT 8M samples at the Seabight deep water station (below 500m) and at the slope stations (see Fig. 10 for note on depths).

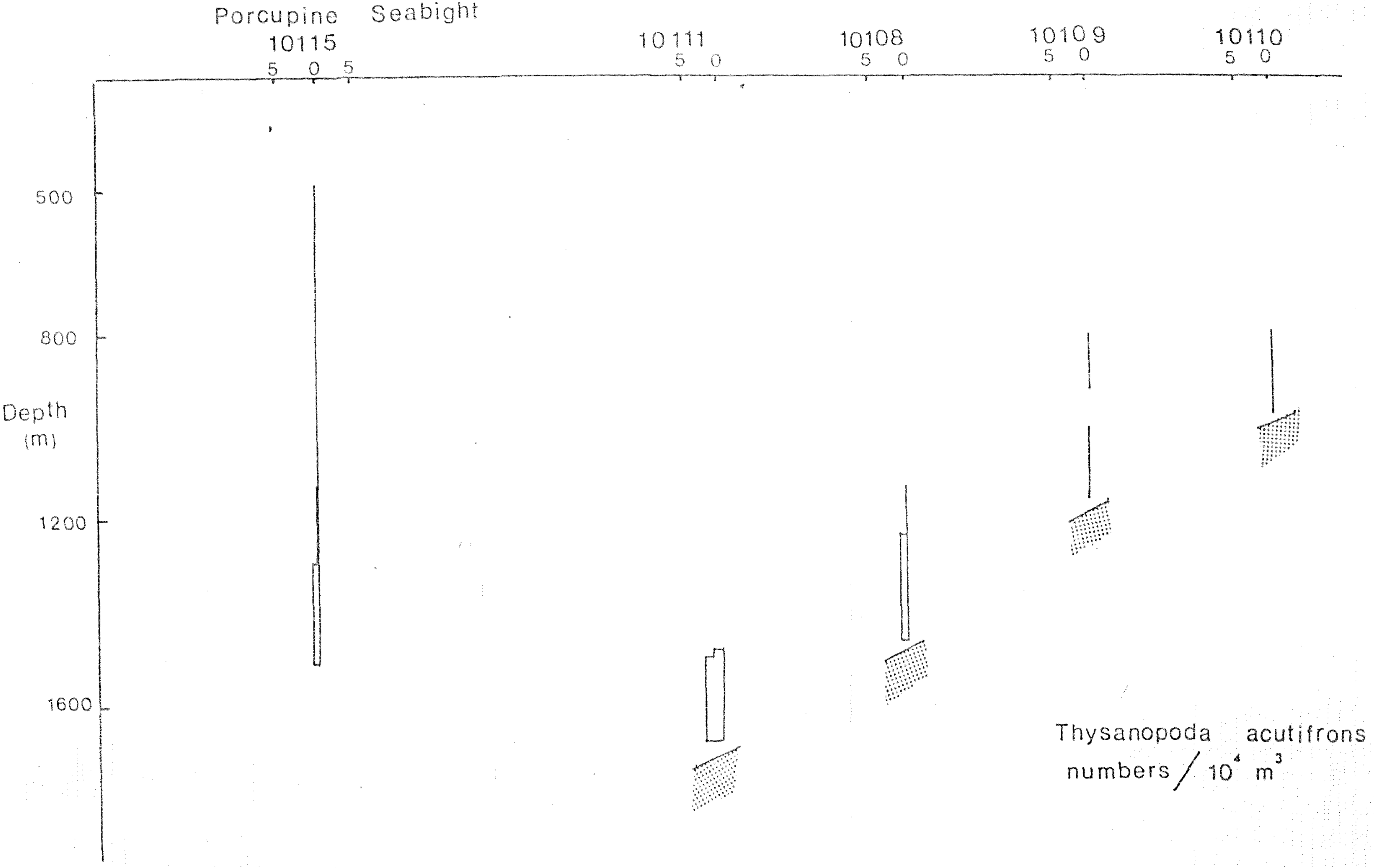

Fig. 38. Profiles (below 500m) of numerical abundance (Nos./$10000m^3$) of Thysanopoda acutifrons in RMT 8M samples at the Seabight deep water station(below 500m) and at the slope stations (see Fig. 10 for note on depths).

stations (10109-10110) it was either absent or sparse, but in the hauls farthest above the sea floor at stations 10108 and 10111 concentrations were slightly higher than those at comparable depths at the deep water station. Closer to the bottom they tended to decrease in concentration except in the deepest haul at Station 10108 (Fig. 37).

Adults of T. microphthalma at the Seabight station occurred mainly at depths of 600-800m; their concentrations were always <0.3/1000m^3. A very few specimens were taken below 800m. Concentrations at the slope stations were also very low.

Similarly concentrations of T. acutifrons were very low throughout the water column in the Seabight but tended to increase slightly with depth. This pattern was repeated at the slope stations (Fig. 38).

1.c.14 Polychaeta (Figs 39, 40, 41, 42)

The profiles for biomass and concentration in the RMT 8M samples were reasonably similar at the two deep water stations (Fig. 39). In the Rockall Trough polychaetes were broadly distributed at 10-900m. By day, maximum numbers (25/1000m^3) occurred at 100-200m but by night around 65/1000m^3 occurred in the surface 100m. Thus, at least part of the population undertook a diel vertical migration. A secondary abundance peak occurred at about 500-900m by day and 500-600m at night, but below 900m concentrations were irregular.

At the Seabight station the vertical range of polychaetes was deeper by day; most specimens occurred between 500-1100m with maximum concentrations of about 10/1000m^3 at 500-700m. At night at least part of the population undertook a diel migration into the surface 200m, but the vertical pattern remained much the same as during the day at 500-900m.

At the deeper two slope stations (10108 and 10111) the concentration profiles were broadly similar to those at comparable depths at the deep water stations showing a sharp reduction in concentration below 1100m. However, at the shallowest slope station (10110) large concentrations of polychaetes occurred in both hauls particularly the one farthest above the sea-bed (Fig. 40). In the shallower hauls at Station 10109 polychaetes were relatively sparse but their concentration increased towards the sea floor. Generally polychaete biomass

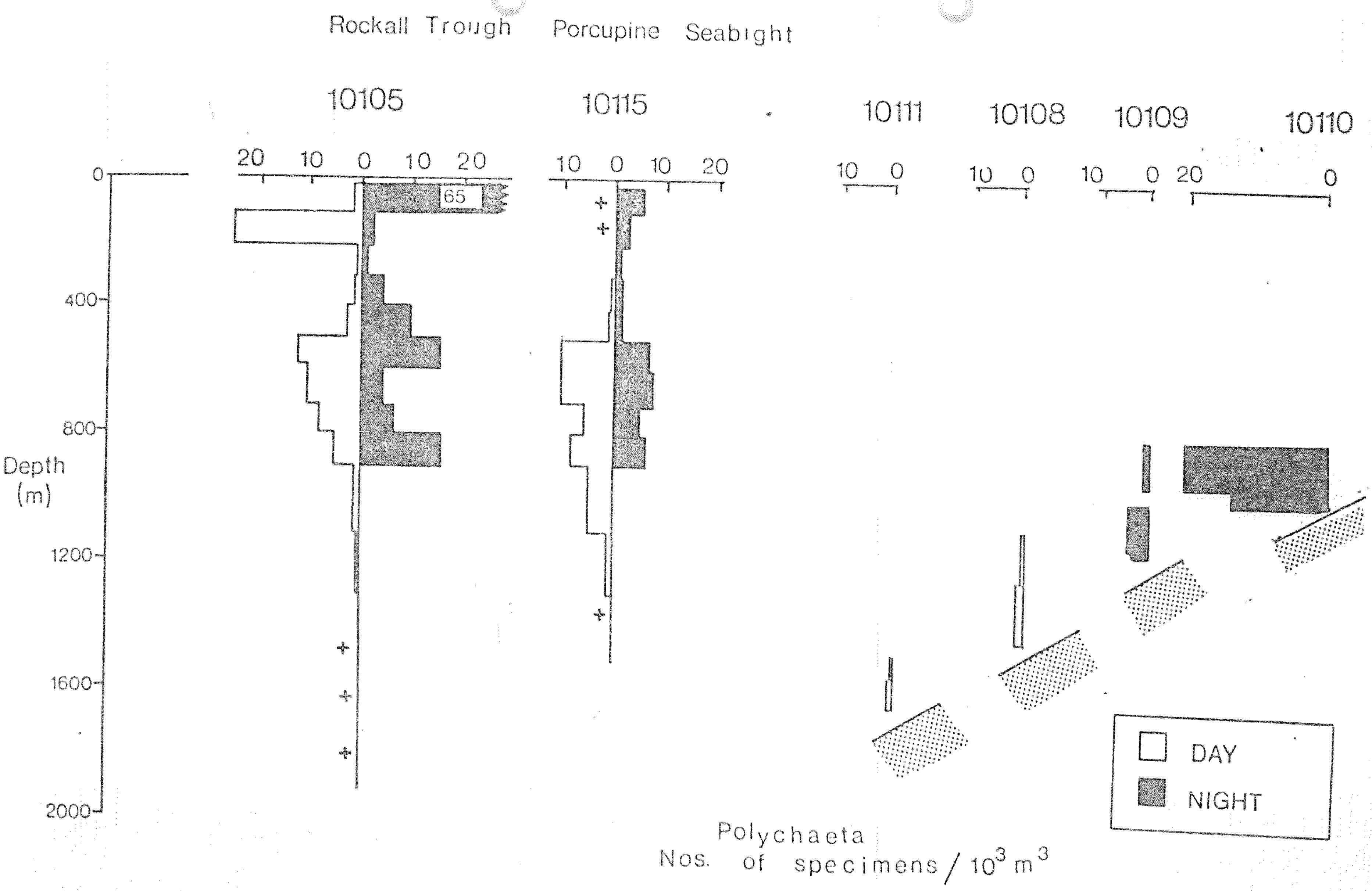

Fig. 39. Profiles of numerical abundance (Nos./1000m^3) of Polychaeta in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

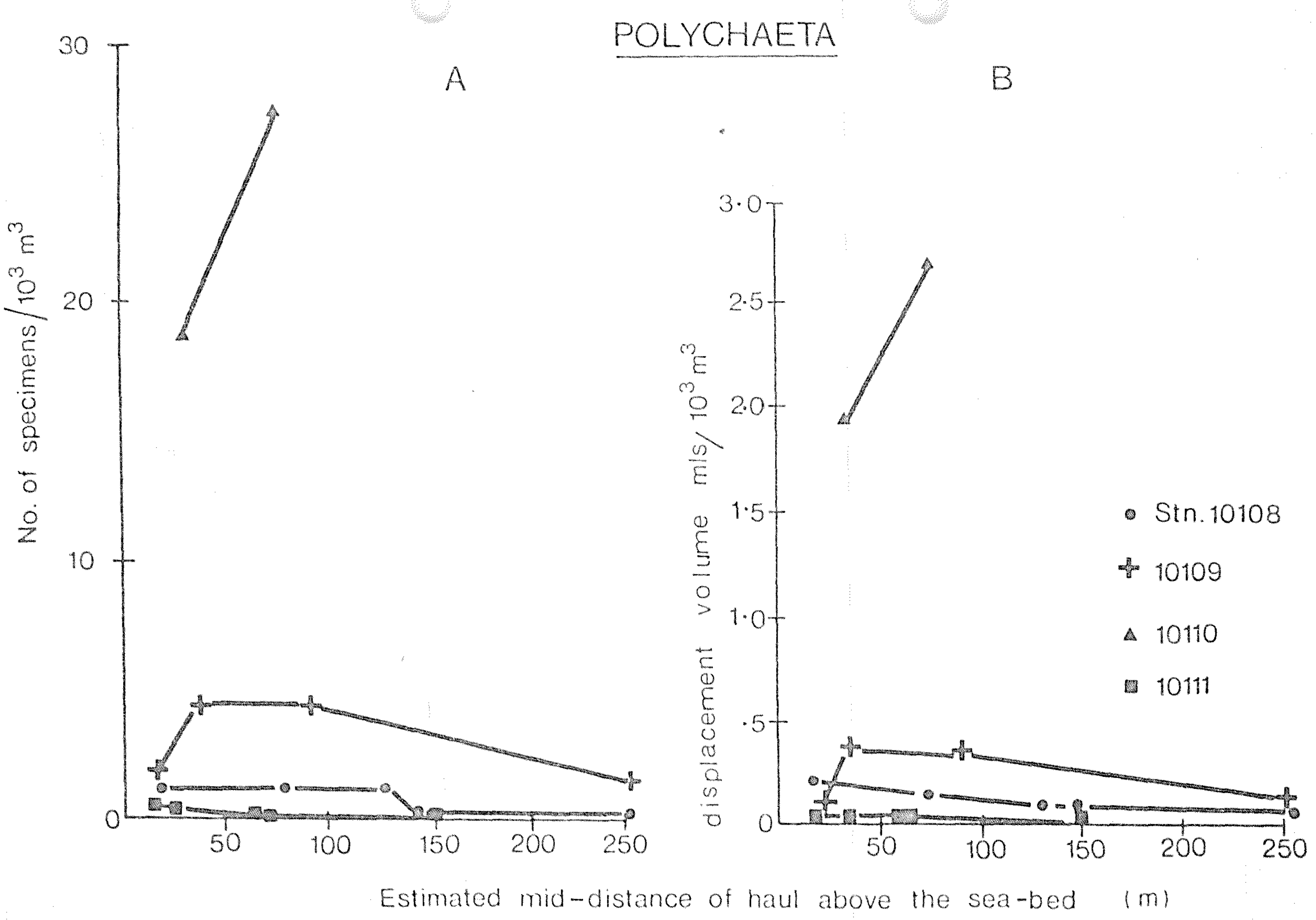

Fig. 40. Polychaeta at slope stations: A. Numerical abundance and B. biomass concentration plotted against average distance above the bottom in metres (RMT 8M).

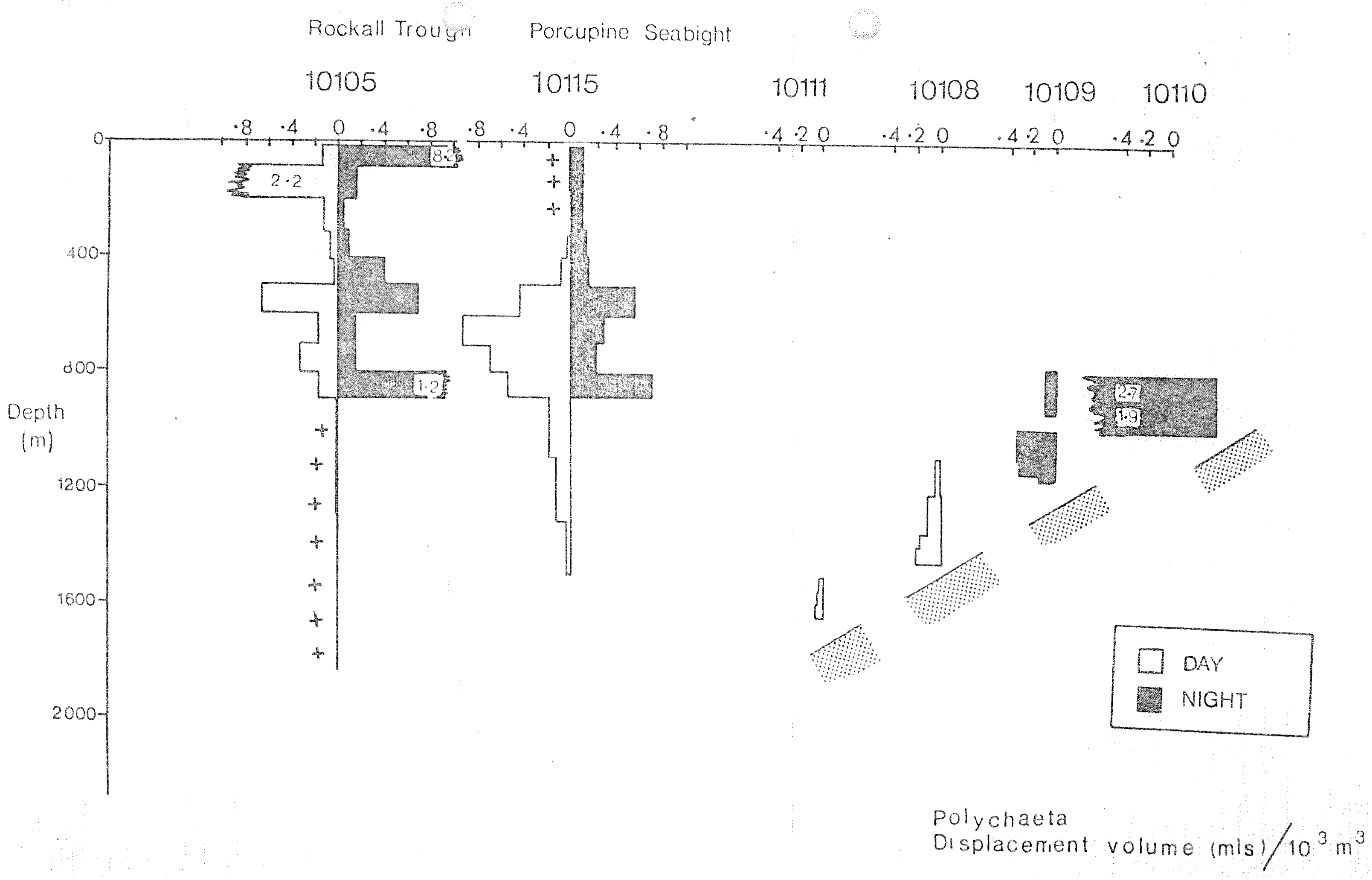

Fig. 41. Profiles of biomass (displacement volume mℓs/1000m^3) of Polychaeta in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

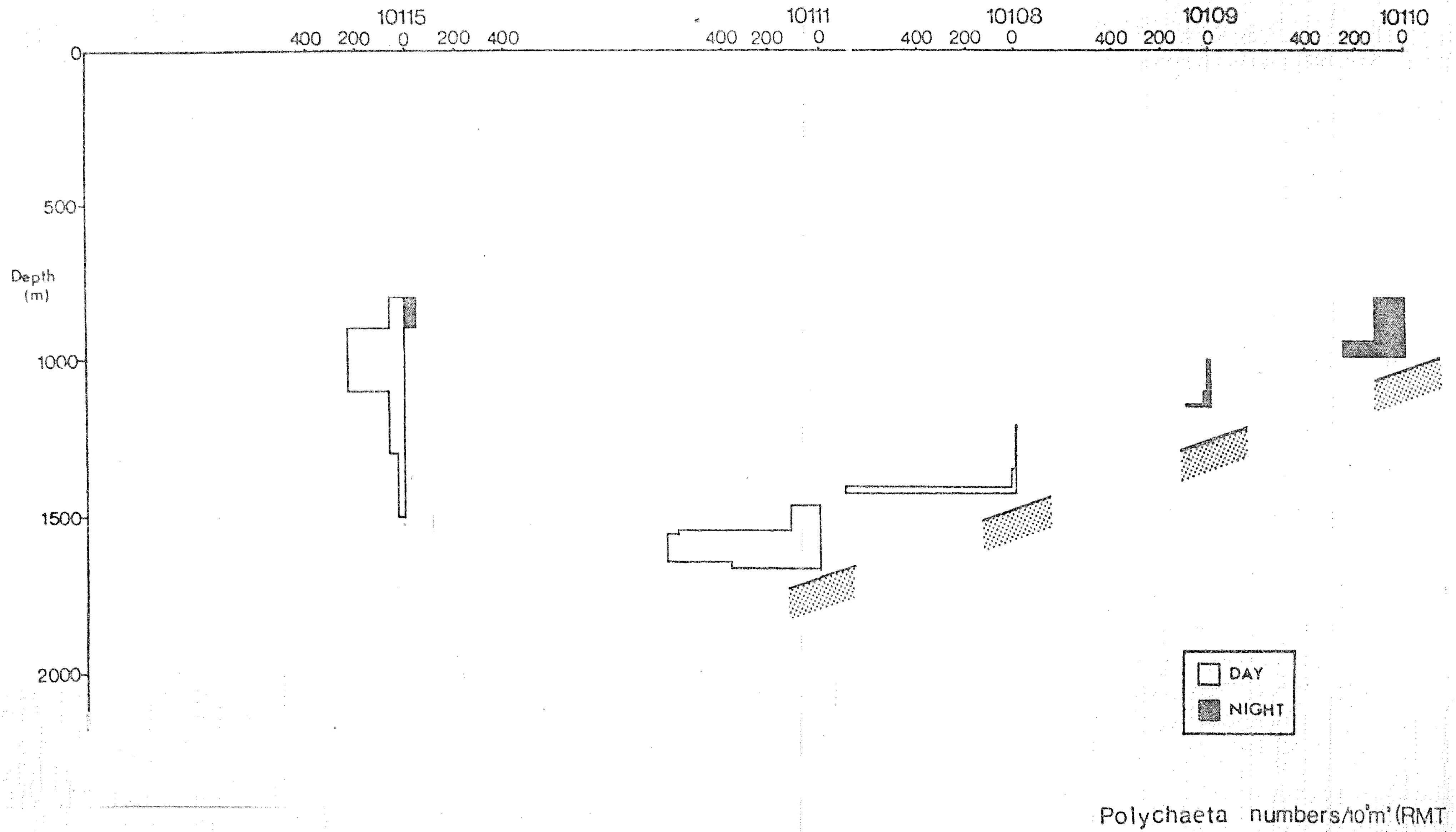

Fig. 42. Profiles of numerical abundance (Nos. /1000m^3) of Polychaeta in RMT 1M samples at the Seabight deep water station (below 800m) and at the slope stations (see Fig. 10 for note on depths).

profiles were similar to the concentration profiles except in the deepest haul at Station 10108 in which the animals were somewhat larger (Fig. 41).

Full species analyses have not yet been completed, but the polychaetes are easily divisible into two main groups, the Tomopterus spp. and the scale worms Lagisca spp. The tomopterids comprised the bulk of the polychaete population and as a group showed rather similar vertical profiles throughout the sampling area. In the Rockall Trough there were two abundance maxima by day at 100-200m and 500-600m and at night in the surface 100m and at 500-900m. In the Seabight both by day and by night tomopterids were present below 500m, but at night a small number had moved up into the surface 100m. Very high concentrations occurred at the shallowest slope station (10110) and there was a slight decrease close to the bottom. Farther down the slope abundances decreased.

The scale worms were less abundant than the tomopterids in the Rockall Trough occurring mainly at 500-900m during the day and at 200-900m by night. In the Seabight they occurred deeper during the day (600-1300m). Over the slope their abundances were generally similar to those at comparable depths at the Seabight station. On the slope the highest concentrations occurred at Station 10110, where there was a very slight decrease close to the bottom. At the deeper stations (10108-10109) fewer specimens were caught but abundances increased slightly near the bottom.

Rather different results emerged from the analyses of the RMT 1M samples in which the slope hauls showed that there was a substantial increase in numerical abundance of small specimens with increased proximity to the sea-bed (Fig. 42). At Station 10111, for example, the numerical abundance 10-25m above the bottom was sixfold the abundance 40-90m above. Similarly at Station 10108 the abundance 15-30m above the bottom was 47-times the abundance to within 90m of the bottom. The numerical abundances observed in the near sea-bed samples were considerably higher than in the vertical series especially at the two deeper slope stations.

1.c.15 Chaetognatha (Figs. 43, 44, 45, 46)

Chaetognaths have been analysed from both the RMT 8M's which samples only the larger forms and the RMT 1M's. In the RMT 8M samples from the Rockall Trough station by day they occurred from 200m to the limit of sampling. The maximum

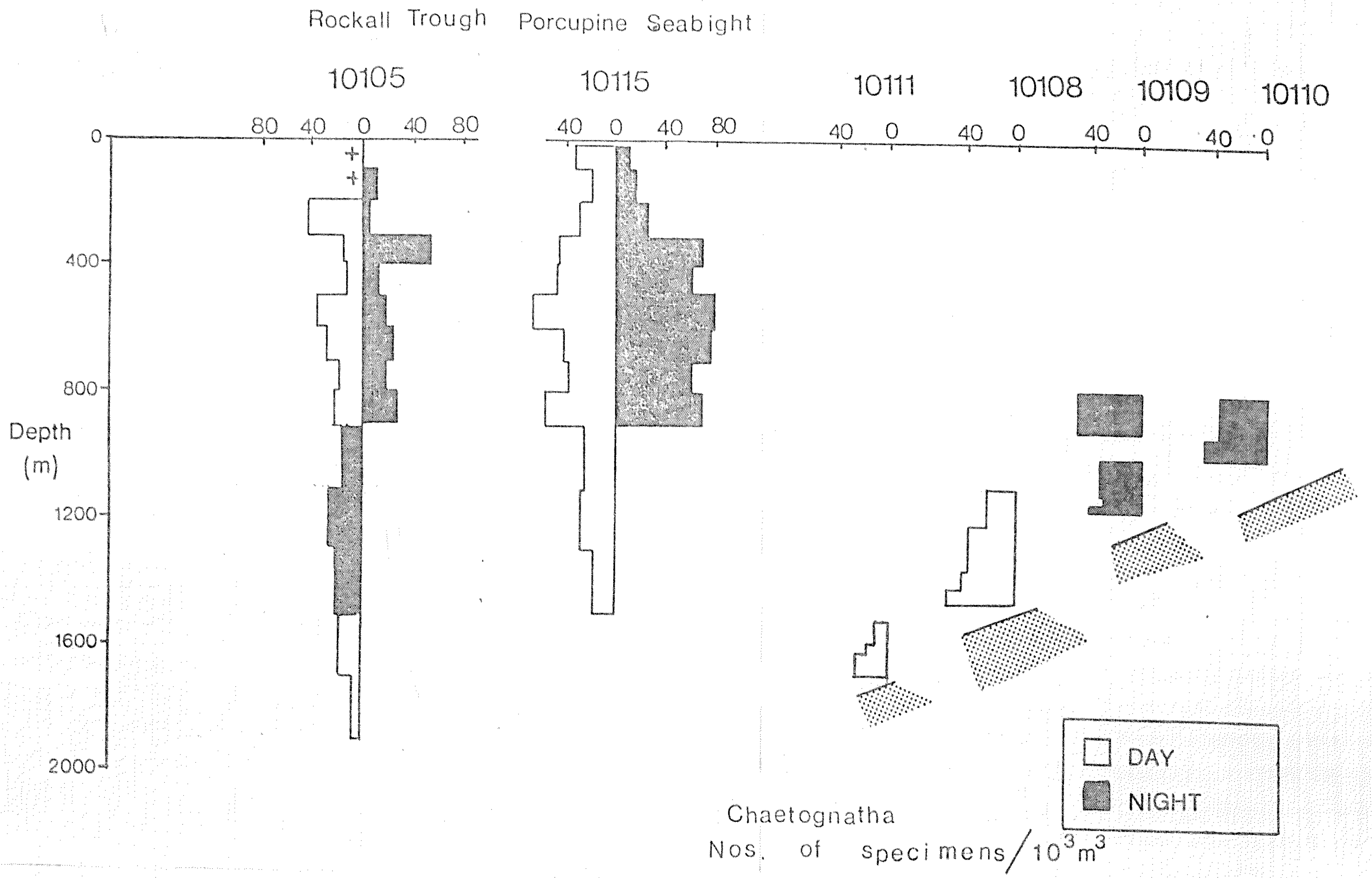

Fig. 43. Profiles of numerical abundance (Nos./$1000m^3$) of Chaetognatha in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

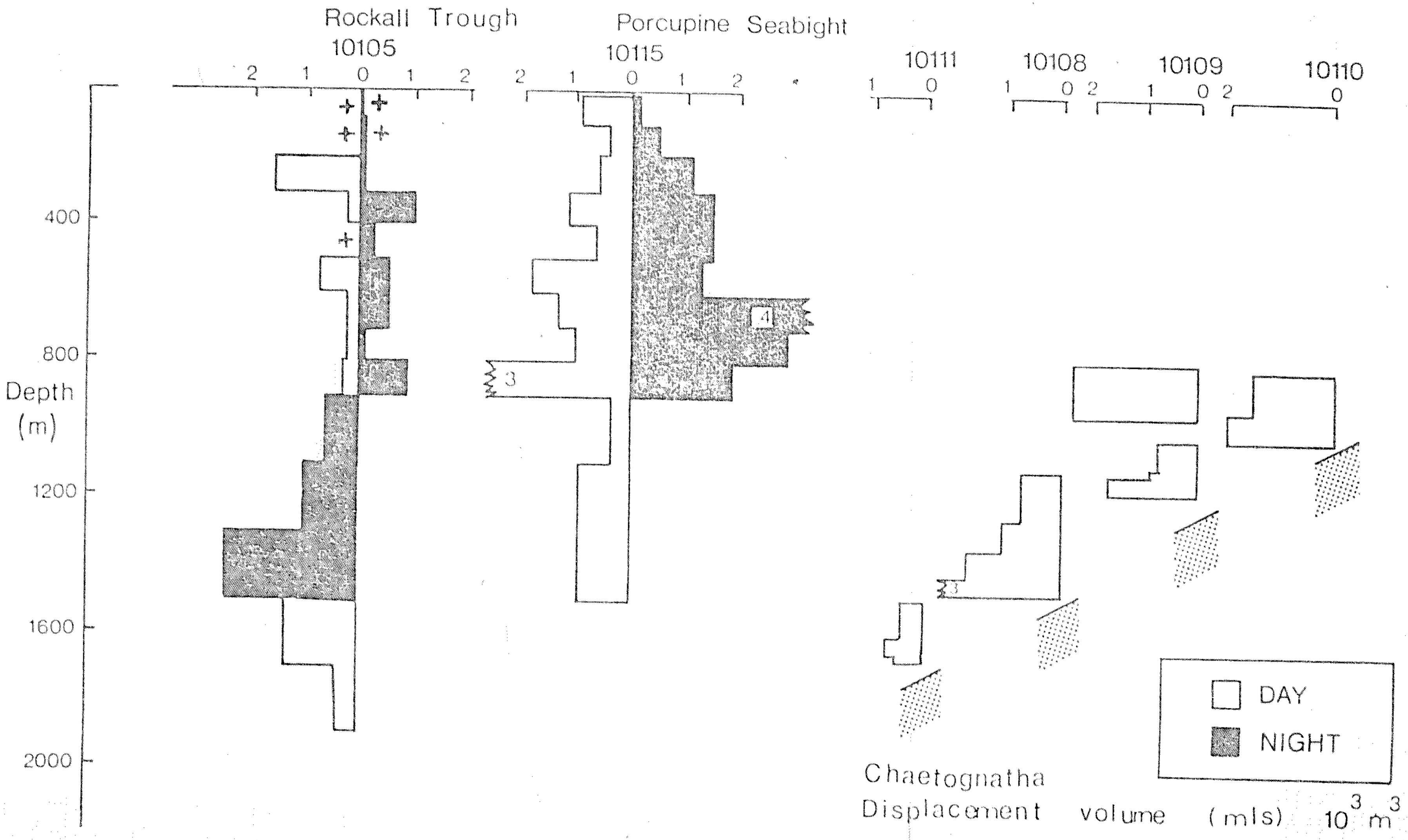

Fig. 44. Profiles of biomass (displacement volume ml's/1000m^3) of Chaetognatha in RMT 8M samples at the deep water and slope stations (see Fig. 10 for note on depths).

CHAETOGNATH

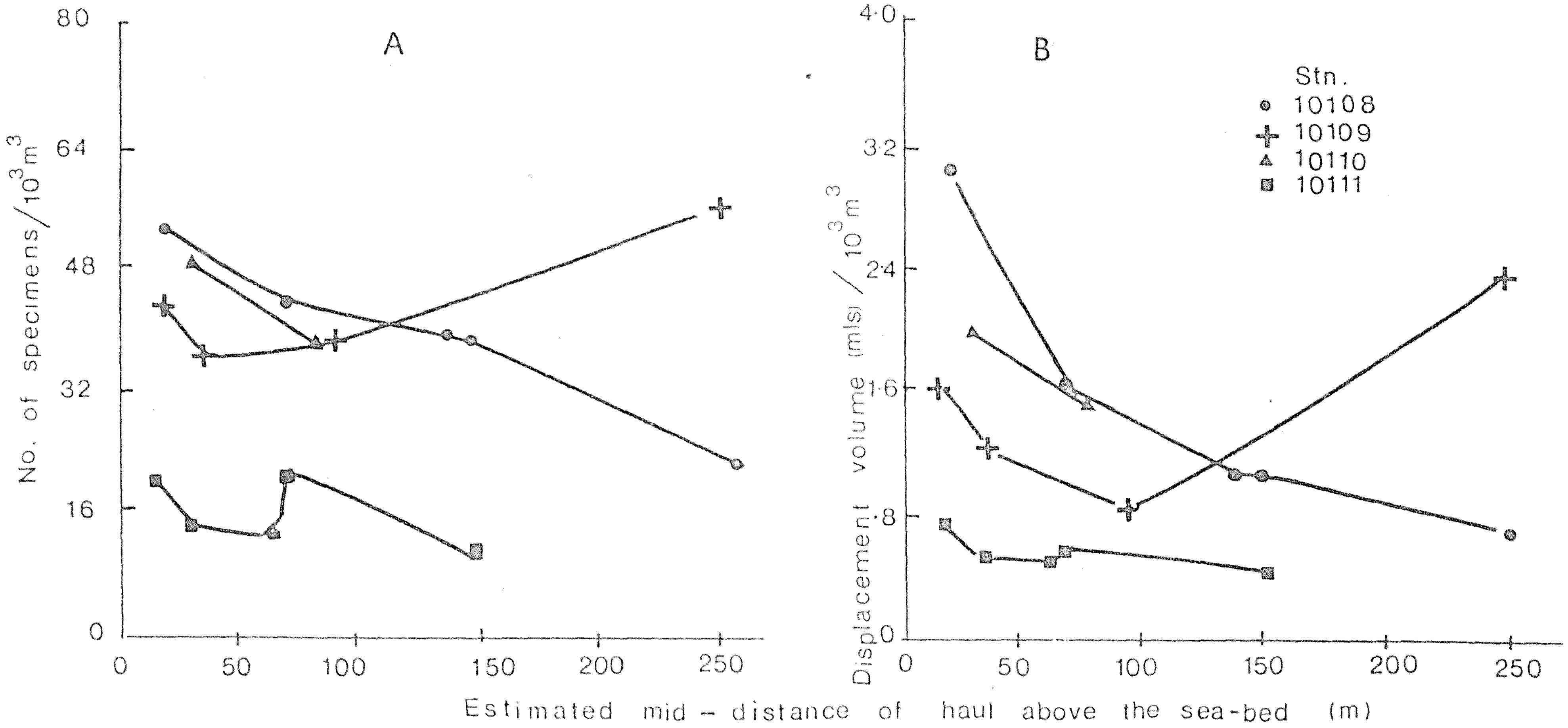

Fig. 45. Chaetognatha at slope stations: A. Numerical abundance and B. biomass concentration plotted against average distance above the bottom in metres (RMT 8M).

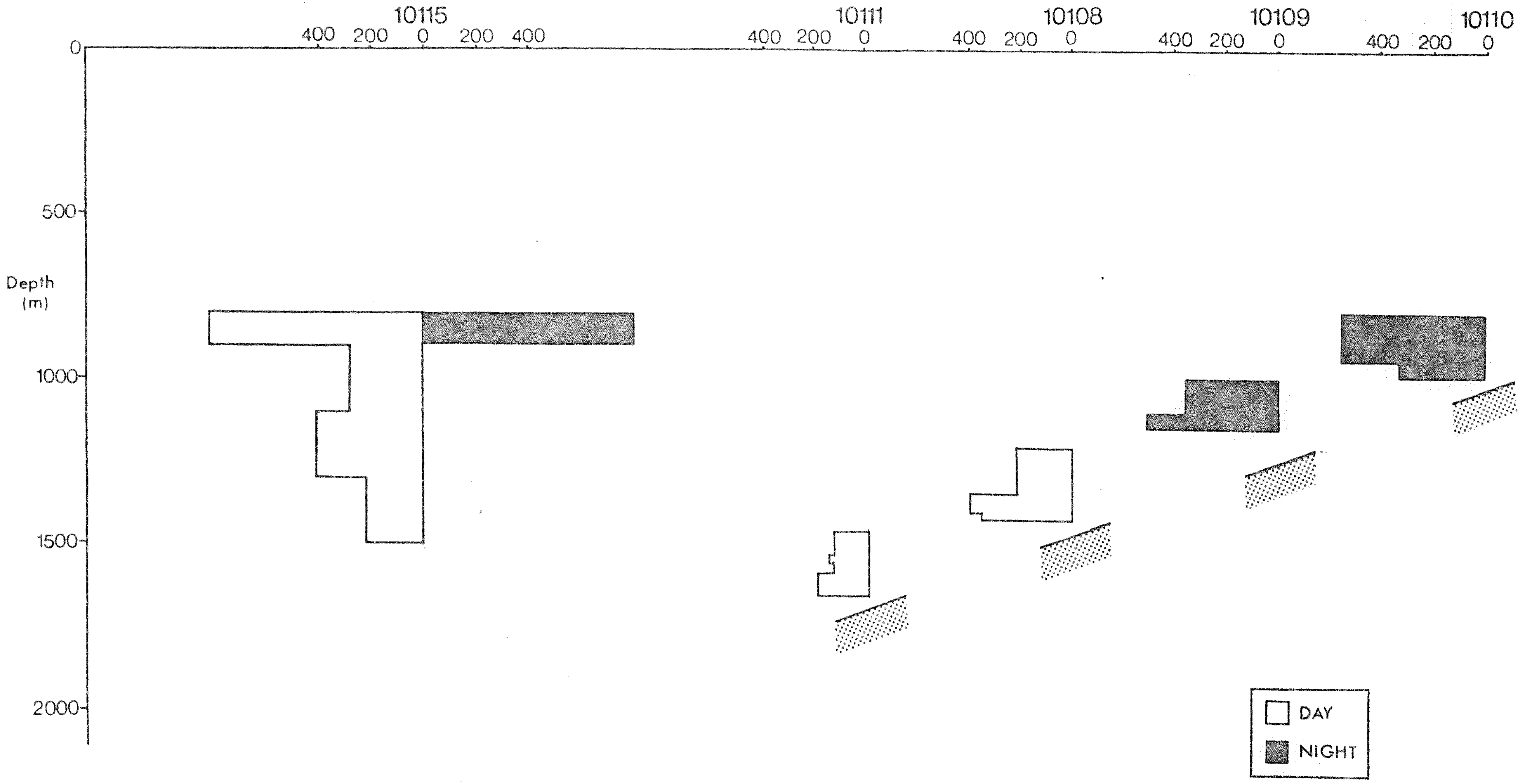

Fig. 46. Profiles of numerical abundance (Nos./1000m^3) of Chaetognatha in RMT 1M samples at the Seabight deep water station (below 800m) and at the slope stations (see Fig. 10 for note on depths).

concentrations were at 200-300m ($44/1000m^3$), and there was a secondary peak at 500-600m ($36/1000m^3$). At night the distribution was more or less similar but several specimens were taken at 100-200m (Fig. 43), indicating a limited diel migration.

At the Seabight station concentrations were higher. In daytime specimens were found throughout the water column with maxima occurring at 500-600m and 800-900m (approximately $60/1000m^3$). At night concentrations were generally slightly greater than in the day hauls, but otherwise the profile was similar.

Chaetognaths were present in all slope hauls. At the shallowest stations (10109 and 10110) concentrations were similar to those at the deep water stations and showed a slight increase towards the bottom. At Station 10108 the increase in concentration was more pronounced towards the sea-bed and abundances were higher than over deep water, whereas at 10111 values were similar to those at the deep water stations (Fig. 43).

In terms of biomass at the deep water station down to 900m the profiles were similar to those for abundance, in some hauls below 900m there was a substantial increase in the average size of the specimens resulting in an increase in biomass relative to abundance (Fig. 44). Over the slope generally biomass profiles were very similar to those for concentration (Fig. 45).

In the RMT 1M catches chaetognaths were the third most abundant group. There was an increase in their numerical abundance close to the sea-bed at three of the slope stations, which was particularly pronounced at Station 10108. This increase did not occur at the shallowest slope station (10110) (Fig. 46). Generally the numerical abundance at all the slope stations differed little from comparable depths at the Seabight station.

SECTION 2

RRS CHALLENGER CRUISE 9/1979

2.a MATERIALS AND METHODS - RRS CHALLENGER CRUISE 9/1979

In July 1979 a series of 6 single samples were collected to within 30m of the sea-bed in the Porcupine Seabight along a north - south transect at longitude 14°W between latitudes of approximately 49°54'-51°40'N (Fig. 47), sampling spanned soundings of 380-4000m. The sampling strategy is shown in Fig. 48 and full details given in Appendix A.

Samples were obtained with the RMT 1+8 (Baker, Clarke and Harris, 1973). The operation of this net is similar to that of the RMT 1+8M except that only a single pair of nets, the RMT 1 and the RMT 8 are operated at each tow. Once again the height of fishing above the bottom was measured by the bottom echo of the monitor signals from the sea-bed, the height was considered to be half the separation between the direct pulse from the monitor and the bottom echo.

Sample processing was the same as for the Discovery Cruise 105 material.

2.b RESULTS - RRS CHALLENGER CRUISE 9/1979

2.b.1 Micronekton biomass

RMT 1 samples have not been analysed so only results from the RMT 8 are available. Data on the total RMT 8 biomass are plotted in Figure 49. Most of the sampling was carried out by day and there appeared to be a maximum of >140mℓs/1000m^3 over a bottom sounding of 686m (Fig. 49). There was a gradual decline in biomass in the deeper hauls to <7mℓs/1000m^3 at 2750m. At 460-495m biomass in the daytime haul was approximately 60mℓs/1000m^3 but at 380-395m which was sampled at night biomass sharply increased to >210mℓs/ 1000m^3; this large concentration at night may have been partially due to a reverse diel vertical migration from shallow depth by day on to the sea-bed at night. The data for the hauls taken between 800-1500m compared to biomass data for Cruise 105 near-bottom hauls show an increase in biomass during the Challenger hauls of 2-3 fold. The high biomass values for all of the Challenger hauls above 1200m were the result of large concentrations of medusae.

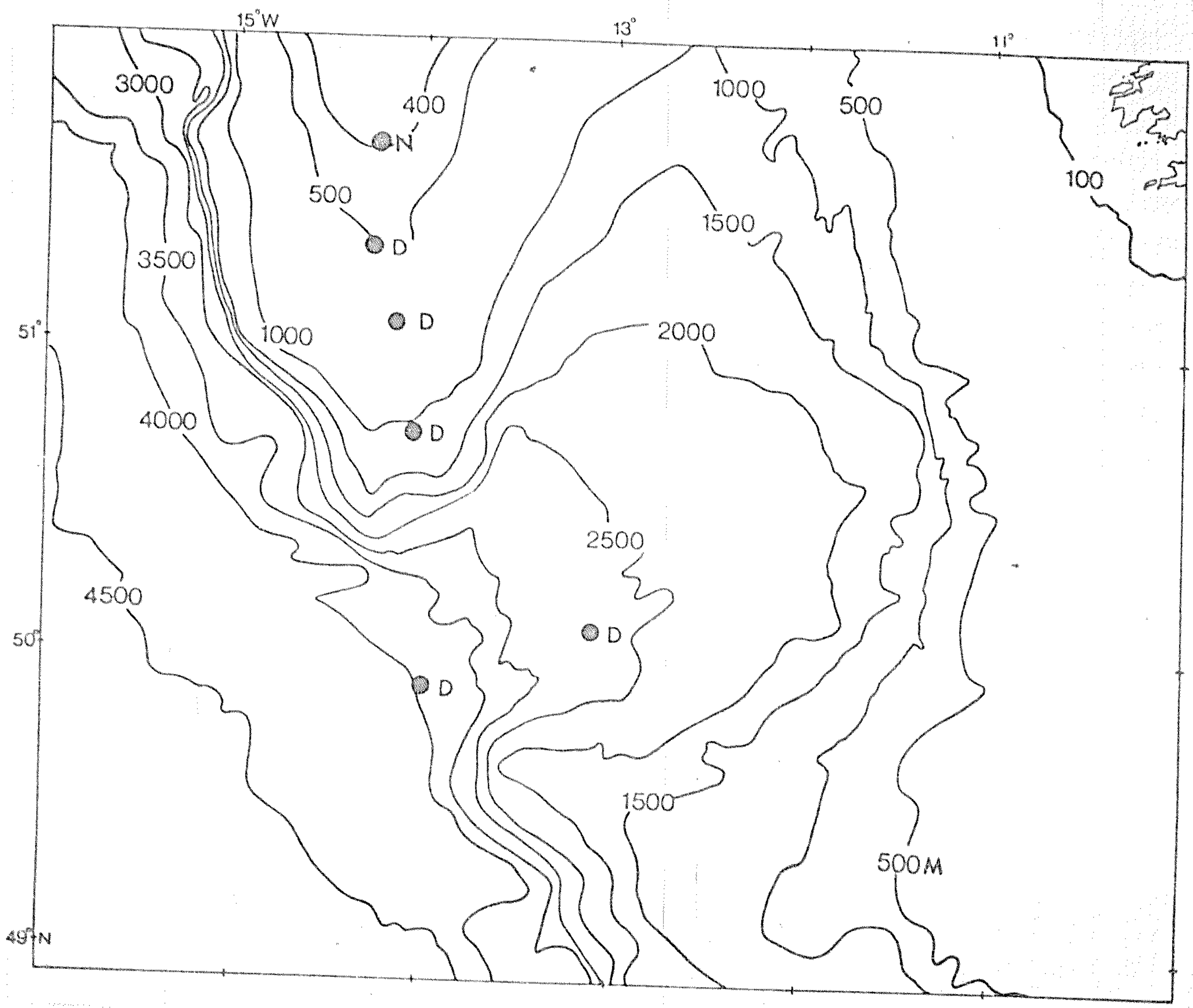

Fig. 47. Bathymetric chart showing the positions of the near-bottom slope stations sampled during the Challenger Cruise July 1979. D = Day N = Night.

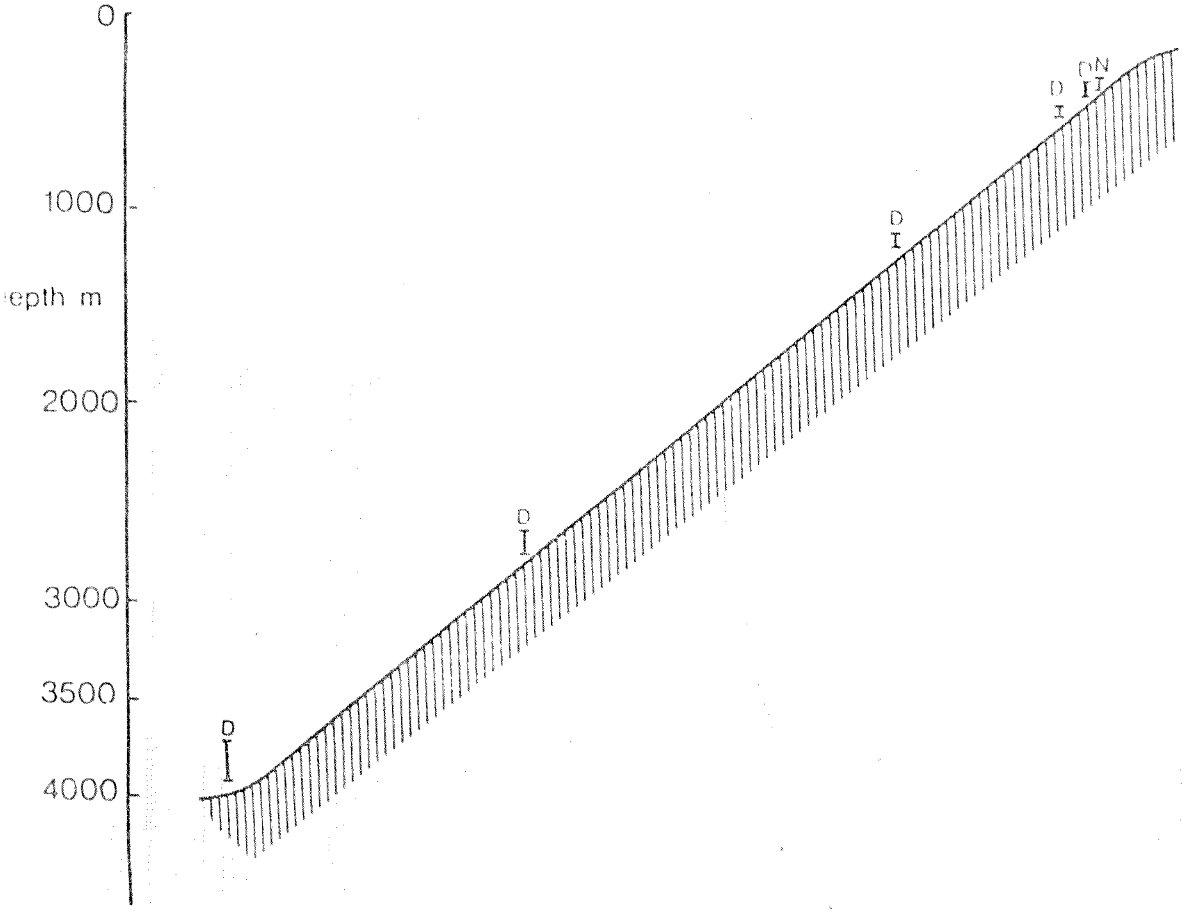

Fig. 48. Diagram to show the relative positions of near-bottom hauls taken during the RRS Challenger Cruise July 1979.

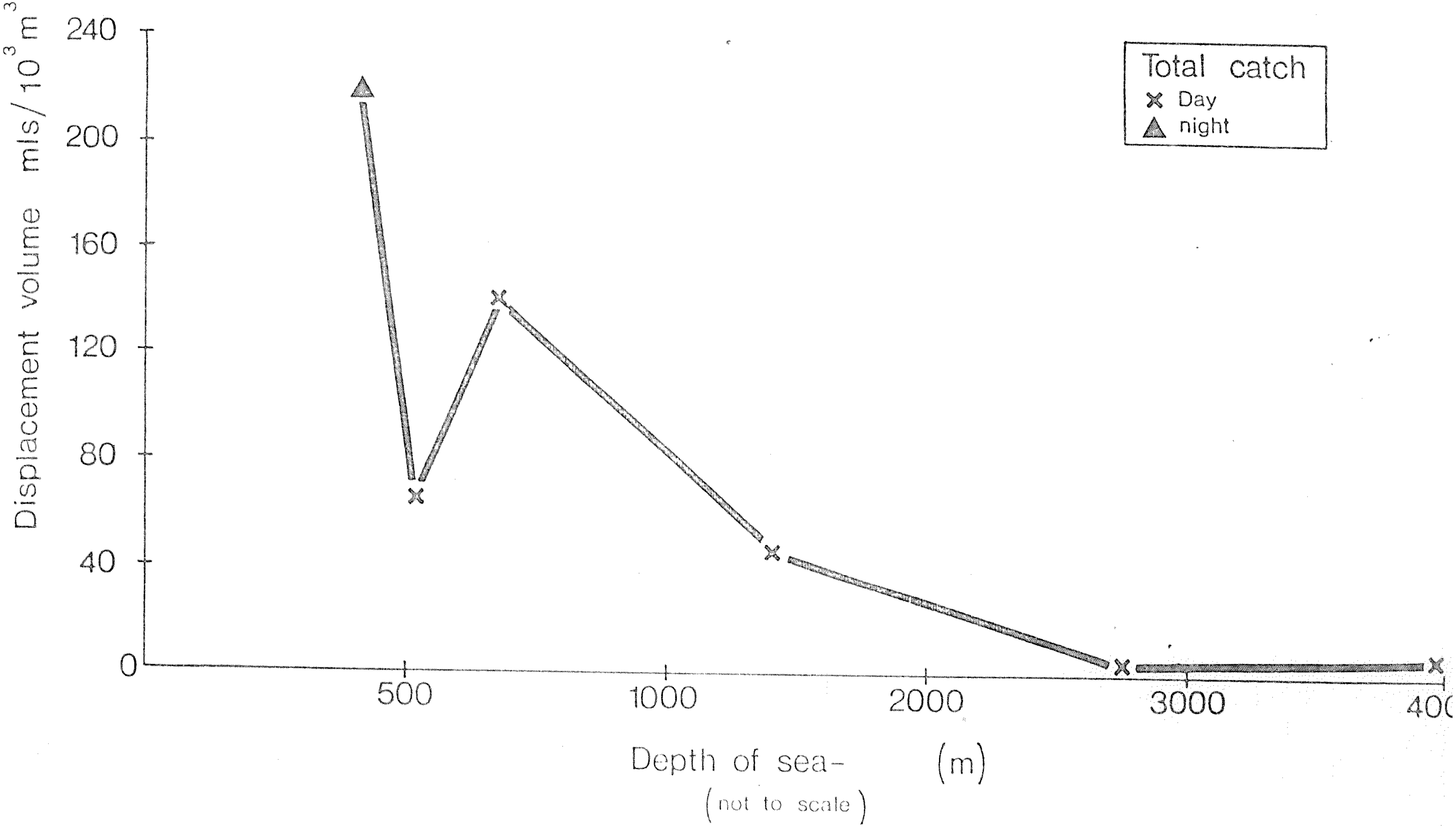

Fig. 49. Profiles of biomass (displacement volume mls/1000m^3) of total micronekton in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

2.b.2 Medusae (Fig. 50)

This group was extremely abundant over this slope especially in the 380-395m night haul and the 460-495m and 655-680m day hauls in each of which >1800 specimens/1000m^3 were taken. Deeper down there was a gradual decline in abundance (Fig. 50). The specific identifications are listed in Table 4. *Aglantha digitale* reached densities well in excess of 1/m^3 at all but the deepest stations. Otherwise the only species that exceeded 10/1000m^3 was *Haliscera bigelowi* at the shallowest station.

Table 4. Numbers of Medusae/1000m^3 identified from Challenger samples obtained during July 1979.

Mid-depth of Haul (m) Species	385	480	675	1120
Aglantha digitale	2883.0	1894.0	2725.0	679.0
Pantachogon haeckeli	1.63	2.49	2.47	1.74
Aegina citrea	3.08	1.00	0.05	0.03
Haliscera bigelowi	17.21	3.00	-	-
Halicreas minimum	-	0.5	-	0.38
Colobenema sp.	0.47	0.5	-	-
Atolla parva	-	-	0.45	0.09
Aeginura grimaldi	-	-	1.53	-
Solmissus incisa	2.73	-	0.45	-

2.b.3 Decapoda (Figs 51, 52, 53, 54, 55)

In daytime maximum abundances occurred in the 460-495m and the 655-680m haul (11 and 14 specimens/1000m^3 respectively). Below these depths there was a sharp decrease in abundance. In the one night tow at 380-395m there was a considerably higher abundance (>77 specimens/1000m^3), (Fig. 51). The specific data are summarised in Table 5.

Gennadas elegans was generally infrequent and its abundance never exceeded 1 specimen/1000m^3 (Fig. 52), values which were lower than in the Discovery

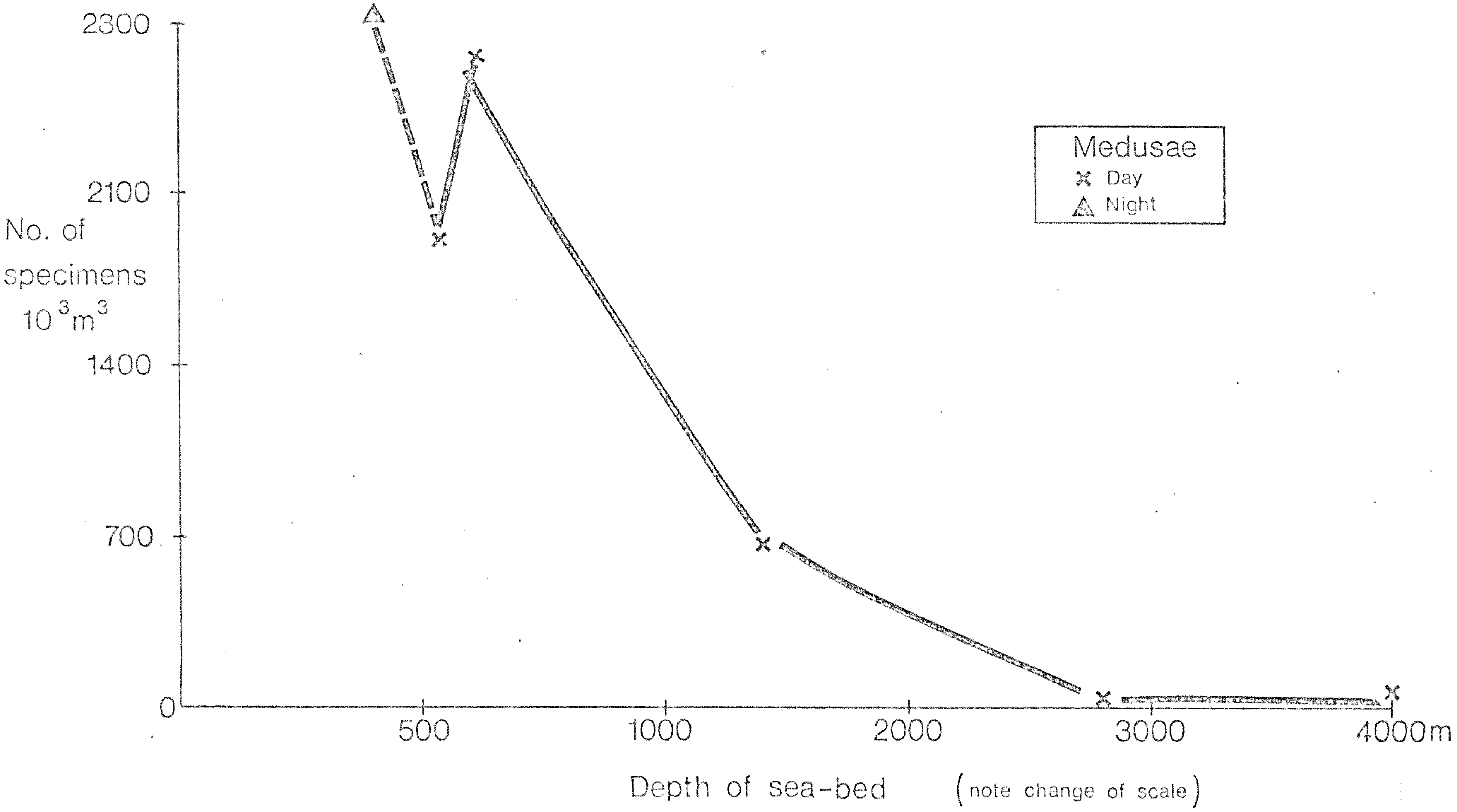

Fig. 50. Profiles of numerical abundance (Nos./1000m^3) of Medusae in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

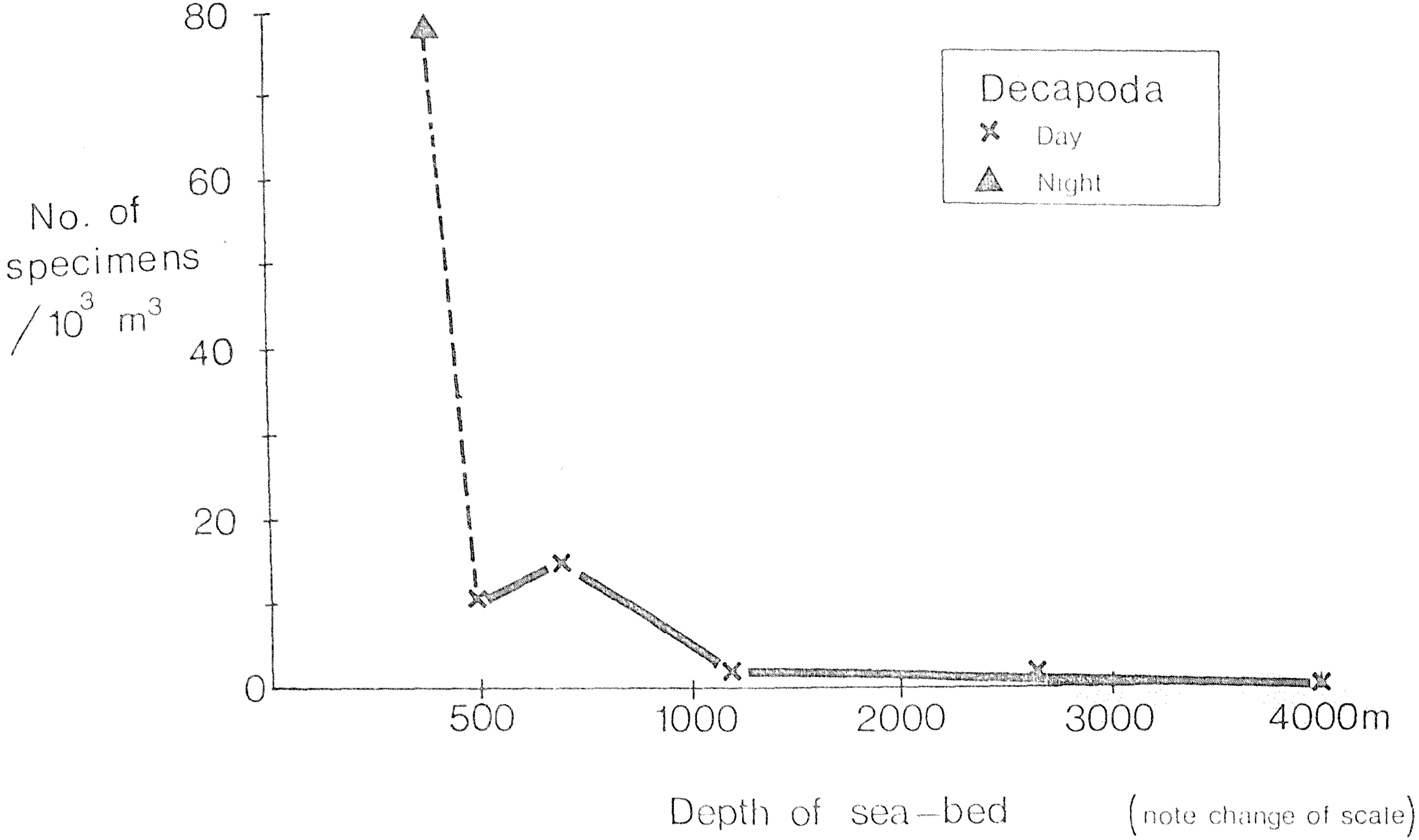

Fig. 51. Profiles of numerical abundance (Nos. 1000m^3) of Decapoda in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

Table 5. Numbers of specimens/1000m^3 of decapod crustaceans taken during the Challenger Cruise 1979. (P = pelagic species, B = benthic species, B/P = benthopelagic species).

		Approximate depth of sea-bed (m)					
Taxa		408	512	686	1195	2770	3980
Sergestes arcticus	(P)	40.10	8.92	5.30	0.62	0.16	0
Gennadas elegans	(P)	1.00	-	0.99	0.31	0.04	0.02
Sergia spp.	(P)	8.11	0.64	2.91	0.10	0.02	0.02
Hymenodora spp.	(P)	-	-	-	-	0.41	0.23
Acanthephyra pelagica	(P)	-	-	0.05	0.03	-	-
Ephyrina sp.	(P)	-	-	-	0.03	-	-
Plesionika sp.	(P)	-	-	0.01	-	-	-
Caridion sp.	(B/P)	3.17	-	-	-	-	-
Pandalus sp.	(B/P)	1.35	-	0.21	0.01	-	-
Pasiphaea sp.	(B/P)	0.17	-	0.40	0.07	-	-
decapod megalopas	(B)	20.60	1.05	4.72	0.07	0.02	0.02
Philocheras sp.	(B)	0.11	-	0.03	-	-	-
Calocaris sp.	(B)	-	-	0.01	-	-	-
Unidentified larvae		0.23	0.23	0.18	-	0.02	0.05

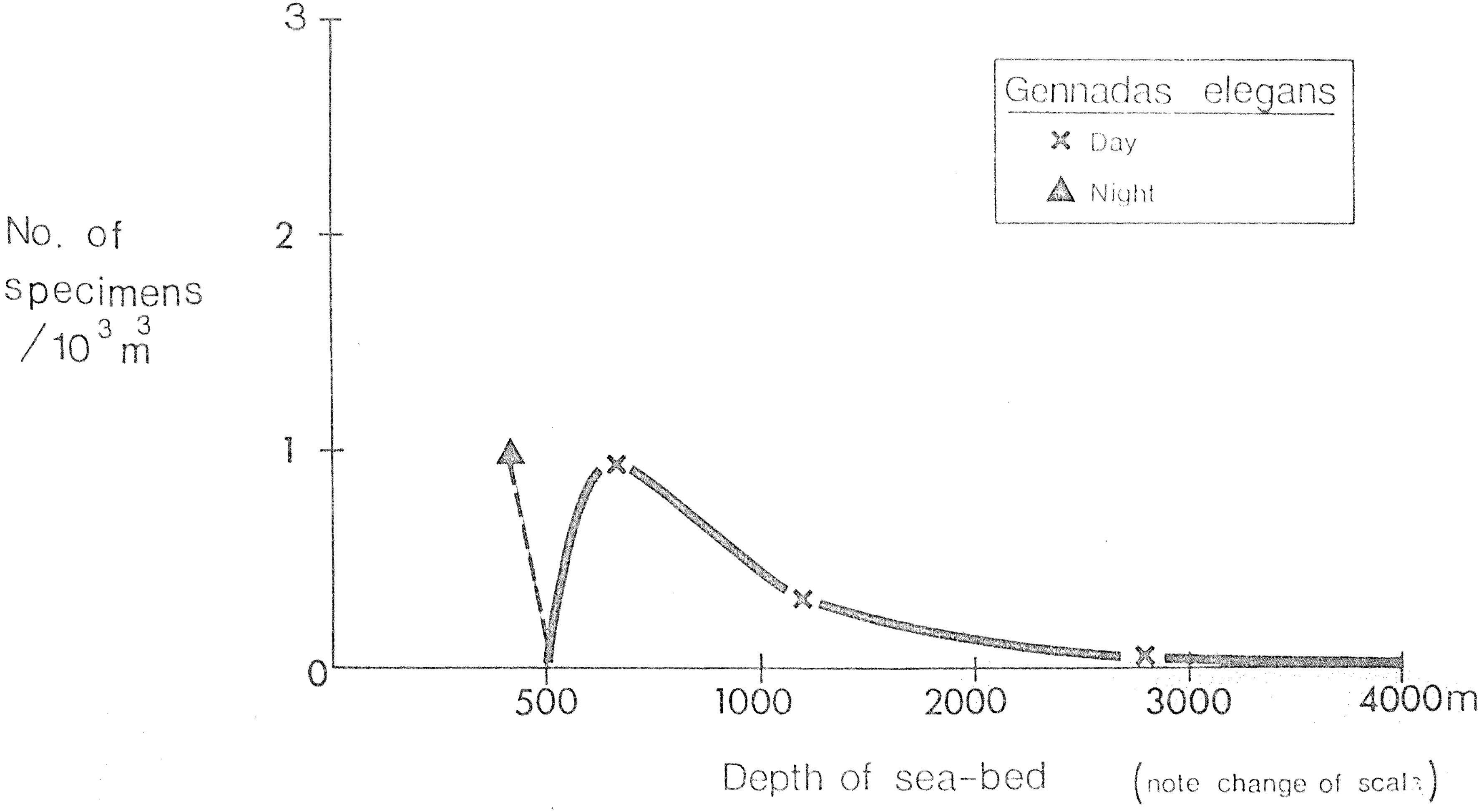

Fig. 52. Profiles of numerical abundance (Nos./1000m^3) of Gennadas elegans in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

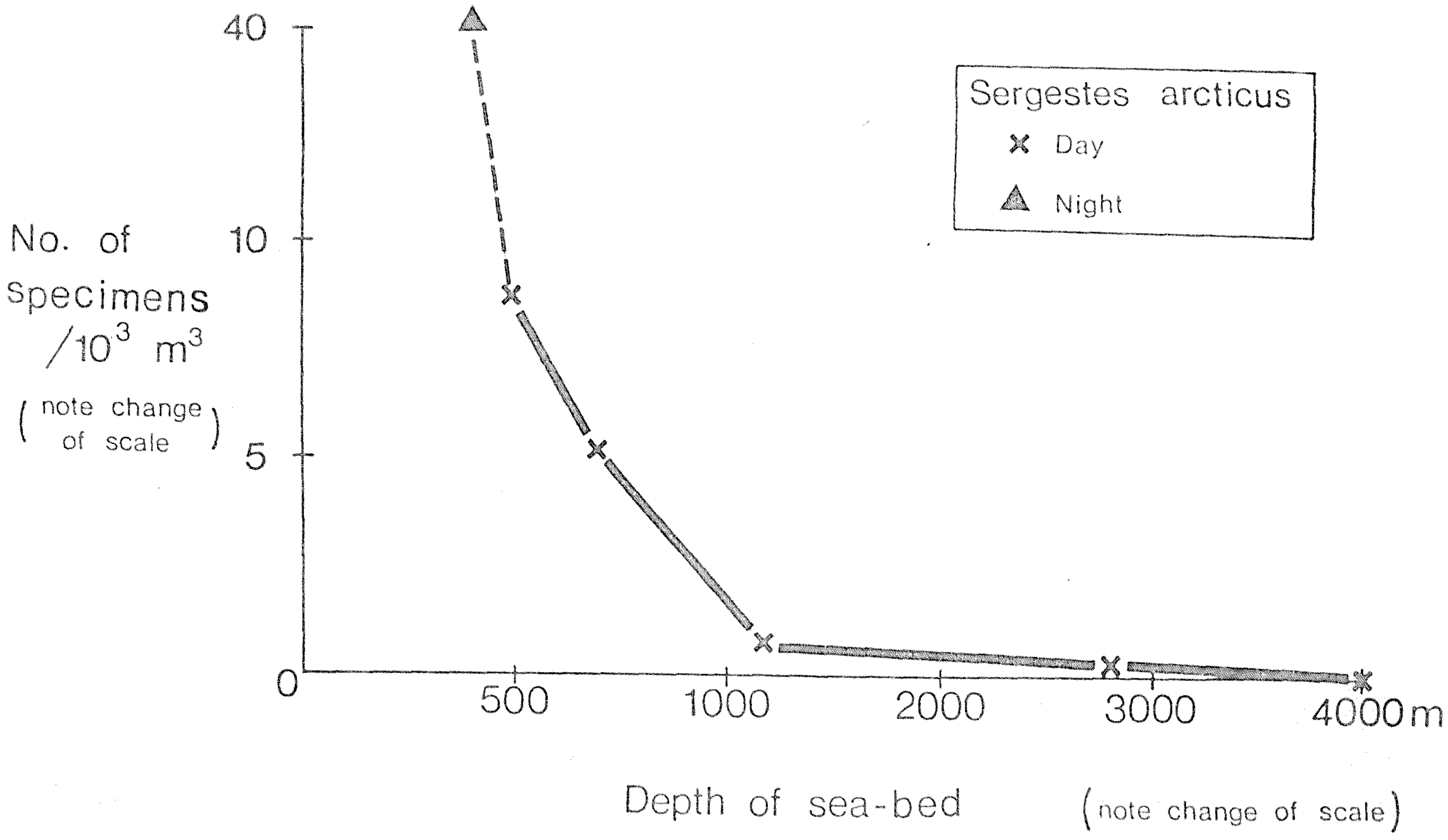

Fig. 53. Profiles of numerical abundance (Nos./1000m^3) of Sergestes arcticus in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

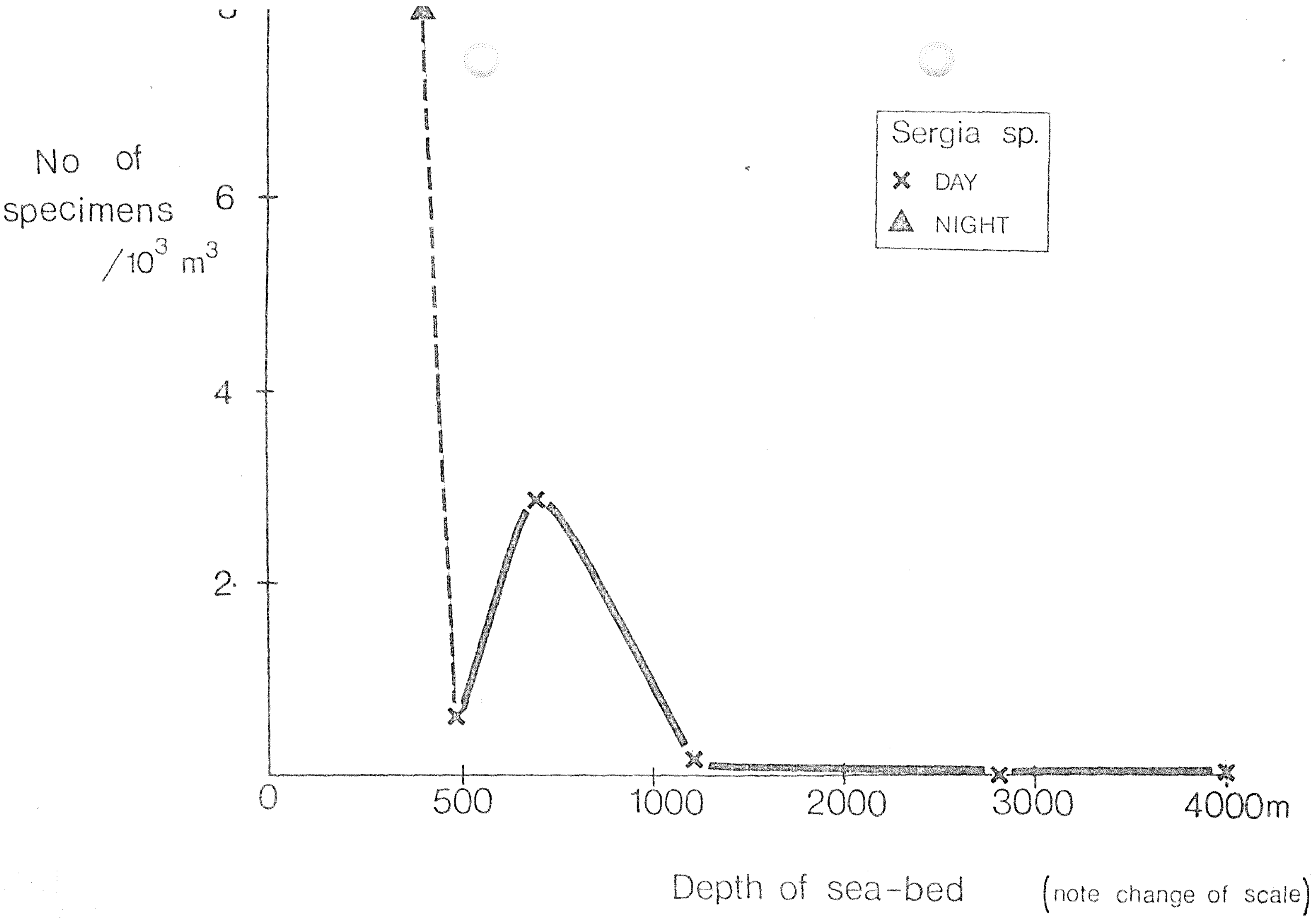

Fig. 54. Profiles of numerical abundance (Nos./1000m^3) of Sergia species in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

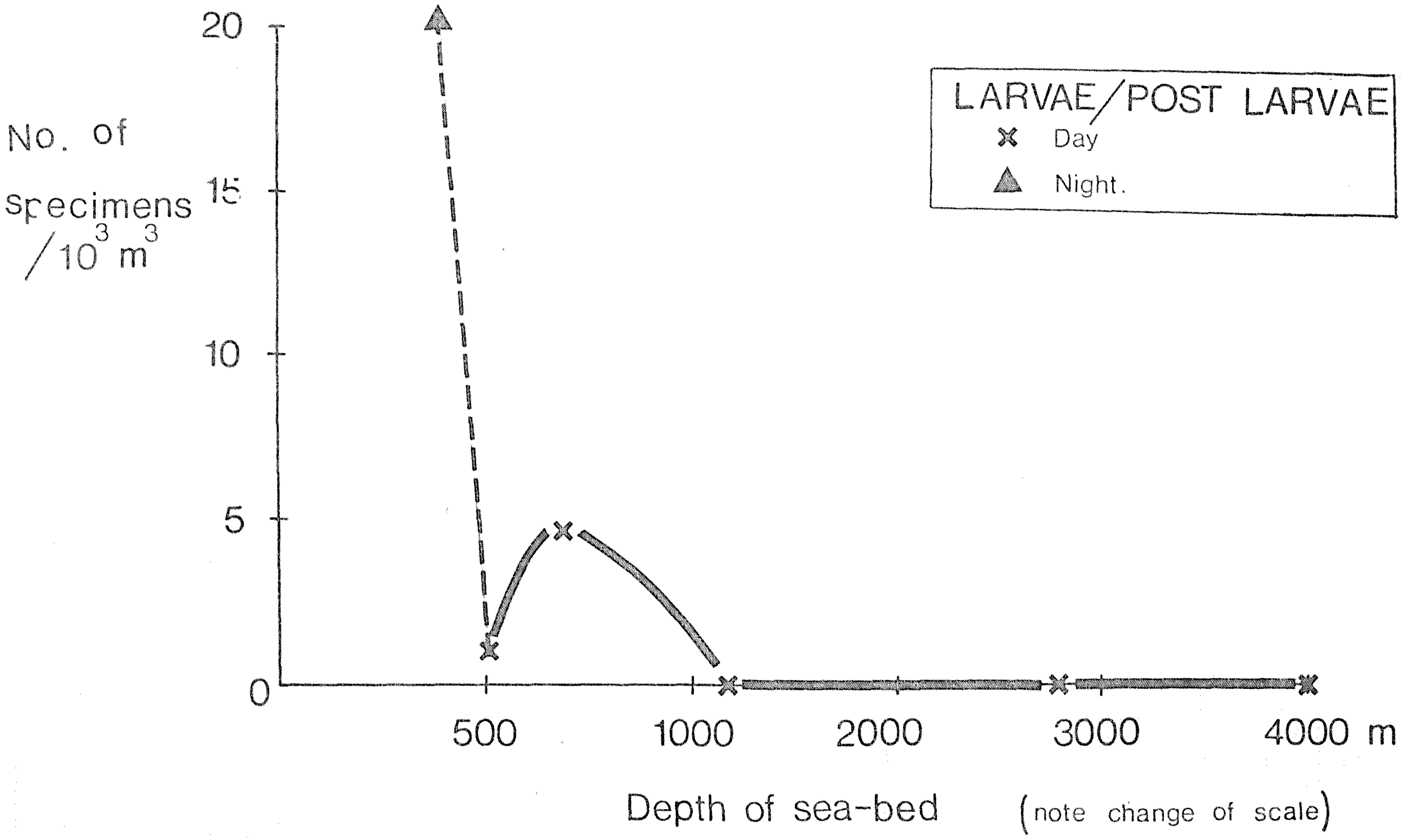

Fig. 55. Profiles of numerical abundance (Nos./$1000m^3$) of larvae and post larvae in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

samples. Sergestes arcticus was much more abundant. During the day maximum concentrations of nearly 9 specimens/1000m^3 occurred in the 460-495m haul (Fig. 53), but much higher concentrations (40/1000m^3) occurred in the 380-395m night haul. Below 495m, there was a gradual decrease in abundance. In the shallower hauls this species was more abundant than at comparable depths at the Seabight stations during Cruise 105 but it was less abundant in hauls from below 1100m. Sergia spp. were present in relatively low concentrations (Fig. 54).

The large 380-395m night haul was particularly interesting in that it contained numerous larval and post larval forms (of which the smaller ones were difficult to identify), including decapod zoeas and megalopas (Fig. 55) and also young specimens attributed to the genus Caridion. These groups are deep-living benthic or benthopelagic species as adults and their high abundance in relatively shallow water may be a seasonal phenomenon. Relatively few post-larvae and no Caridion species occurred in the Discovery samples collected a few months later. Although we tentatively consider this to be a seasonal effect, it could also be the result of swarming or the passive aggregation of these larvae by water currents.

2.b.4 Mysidacea (Figs 56, 57, 58)

This group was only abundant in the 655-680m haul (14 specimens/1000m^3) (Fig. 56). The majority of specimens were Eucopia hanseni (Fig. 57) which was slightly more abundant in these Challenger samples than in the later Discovery samples but many of the specimens were immature. At least four species of the genus Boreomysis (Fig. 58) occurred. This genus is known to have a wide vertical range and this was apparent from its distribution. Several other genera were represented but only in very low concentrations.

2.b.5 Euphausiacea (Figs 59, 60)

Euphausiids were most abundant in the 380-395m night haul, the shallowest station sampled (>20 specimens/1000m^3), and there was a gradual decrease in abundance with depth (Fig. 59). Ten species occurred in the shallow haul with a Thysanopoda sp. the dominant form (Fig. 60). These Thysanopoda specimens could not be identified to species because of their immaturity, but they may have been Thysanopoda acutifrons, adults of which occurred in the 1090-1160m haul.

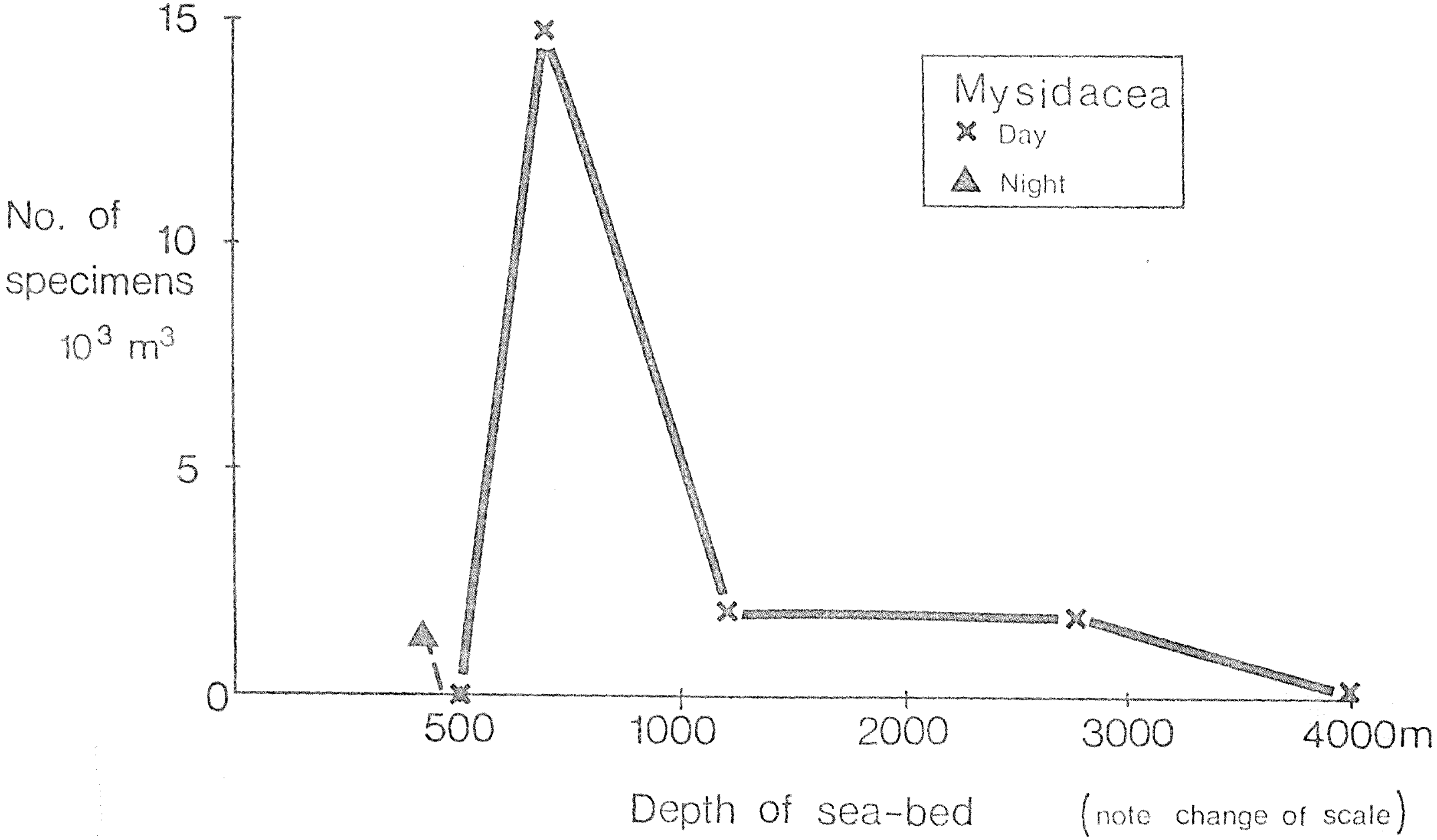

Fig. 56. Profiles of numerical abundance (Nos./1000m^3) of Mysidacea in RMT 8 samples es taken near-bottom over the slope, plotted against depth of the sea-bed.

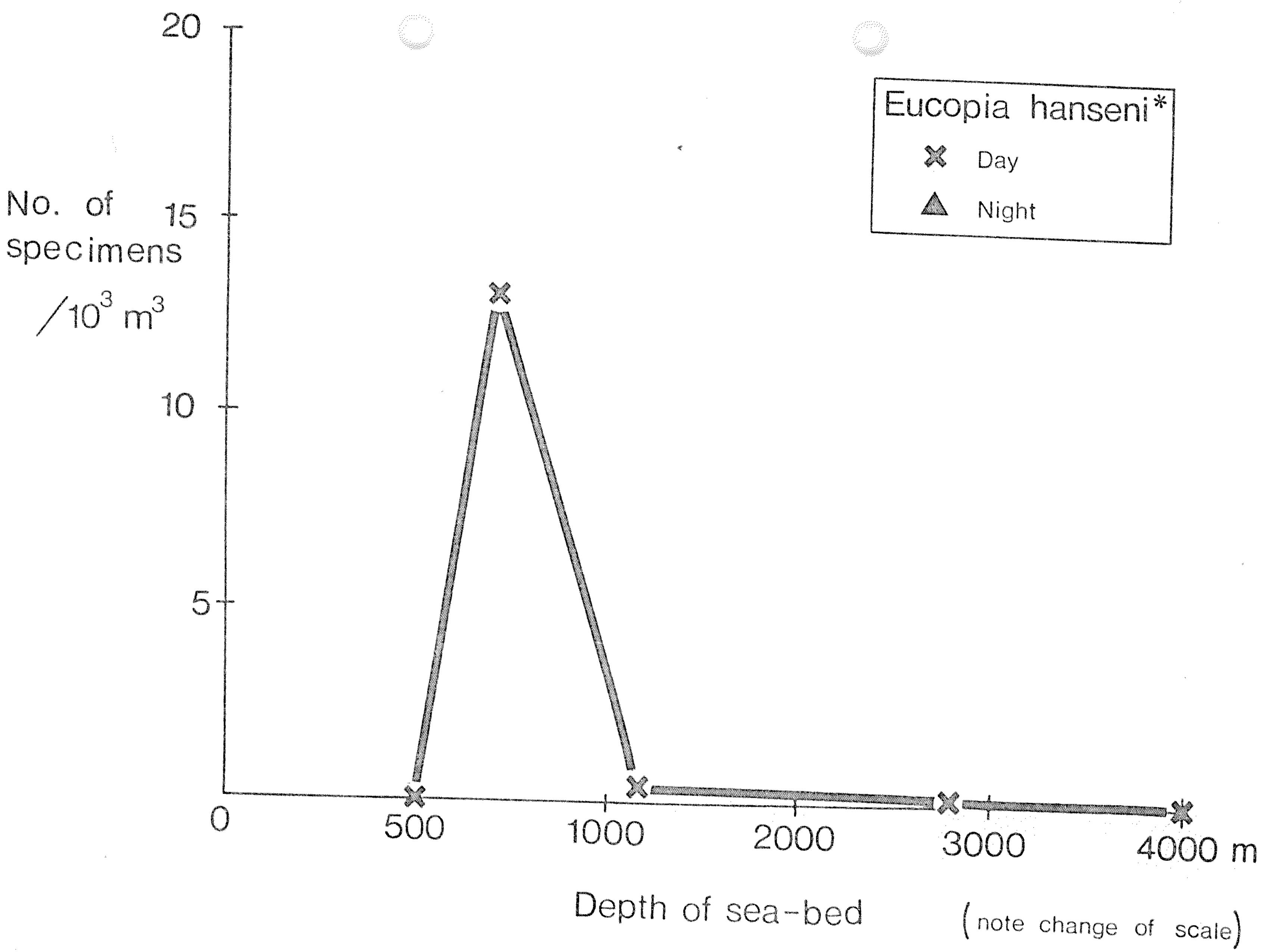

Fig. 57. Profiles of numerical abundance (Nos./$1000m^3$) of Eucopia hanseni in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed. *E. hanseni is considered to be synonymous with Eucopia unguiculata.

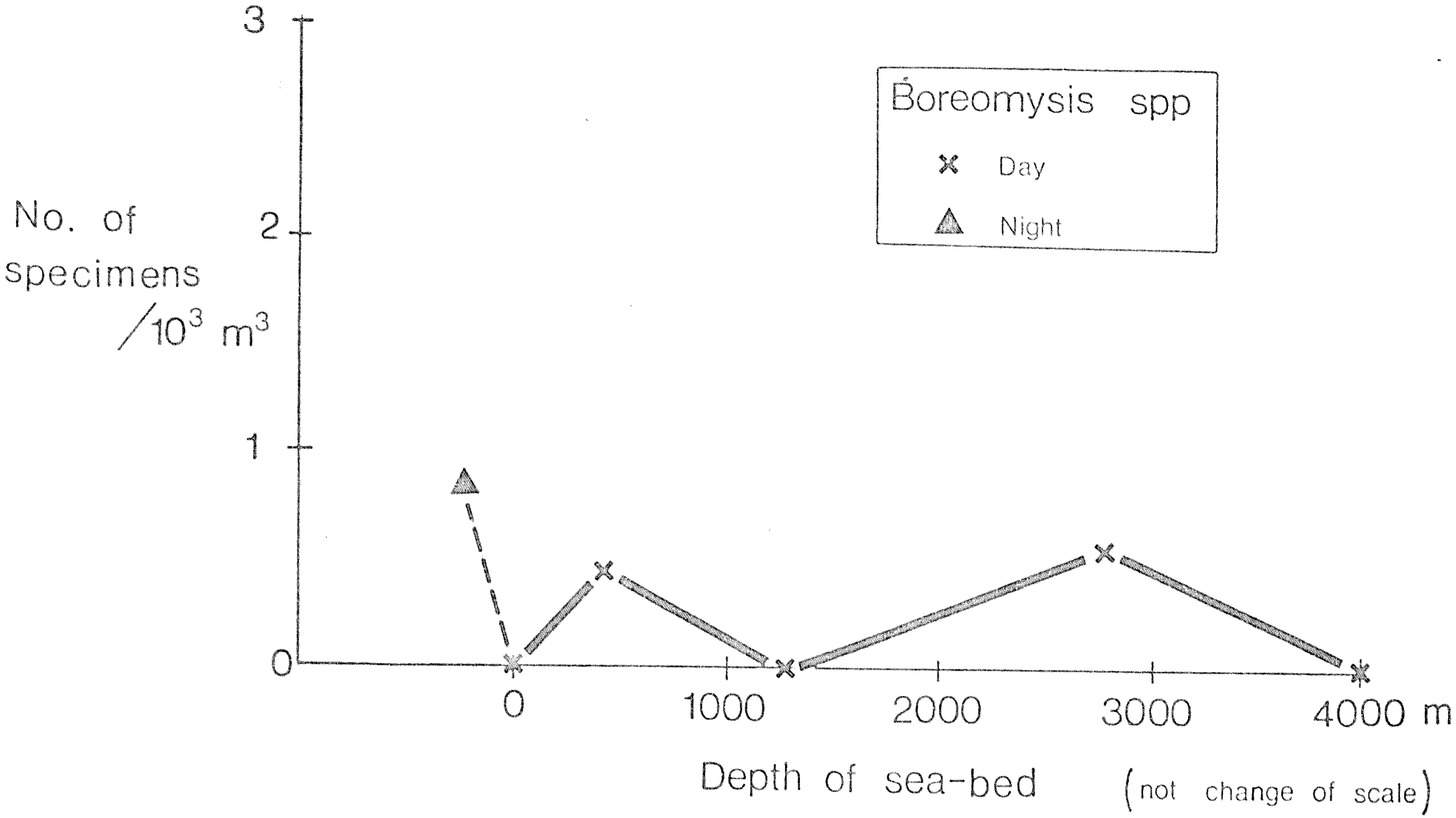

Fig. 58. Profiles of numerical abundance (Nos./$1000m^3$) of Boreomysis species in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

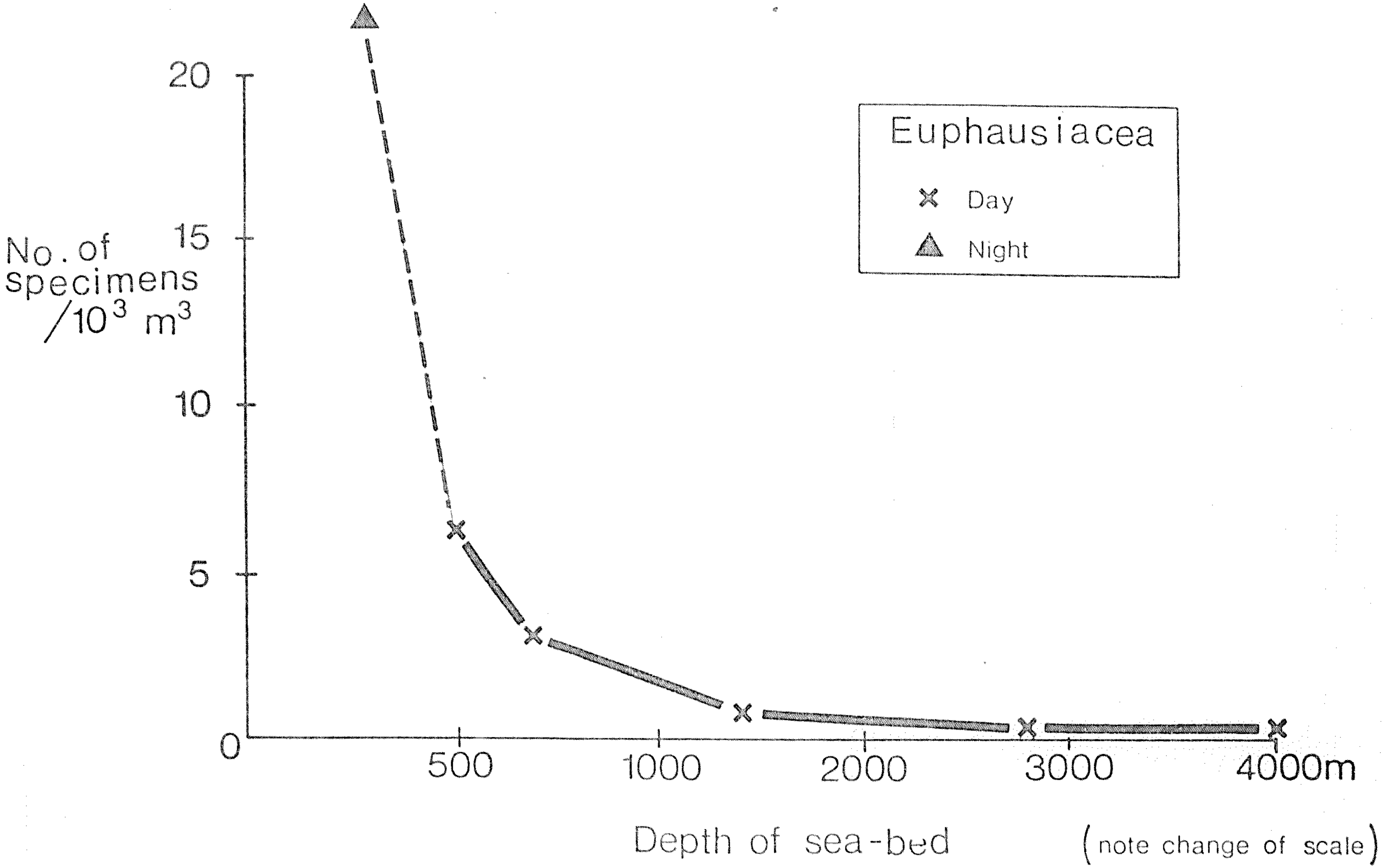

Fig. 59. Profiles of numerical abundance (Nos./1000m^3) of Euphausiacea in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

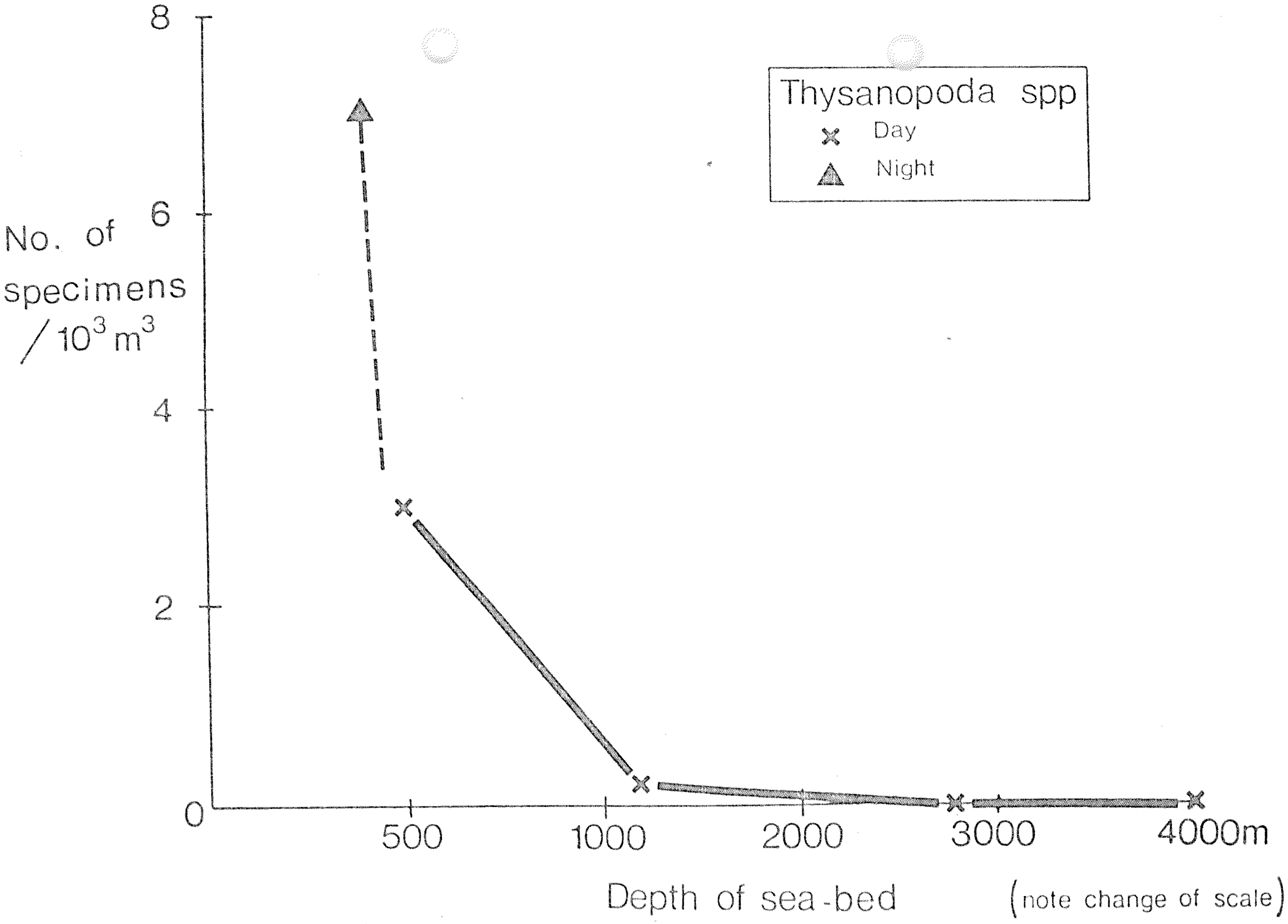

Fig. 60. Profiles of numerical abundance (Nos./1000m^3) of Thysanopoda species in RMT 8 samples, taken near-bottom over the slope, plotted against depth of the sea-bed.

2.b.6 Polychaeta (Fig. 61)

Polychaetes were most abundant in the 655-680m haul, deeper there was a gradual decrease in abundance to a minimum at approximately 2900m (Fig. 61). These specimens have not been identified to species level.

3. DISCUSSION

Wishner (1980) in her report on plankton collected by a small net attached to 'Deep-Tow' was the first to describe an increase in plankton abundance in close proximity to the sea-bed in deep water. This was also observed by Angel and Baker (1982) in one of their total water column profiles from a depth of 4000m off N W Africa. The biological significance of this observation is that the sea-bed, by acting as a collector of sedimenting large and small particles becomes a zone relatively enriched with organic material. There is some debate as to whether it is the rain either of very fine particulates as collected by sediment traps, or of coarser particulates such as large faecal material or 'snow' aggregates, or even large corpses which provide the most important input of organic material into the benthic and benthopelagic ecosystems, (e.g. Angel in press). However, it is clear that the distribution of biomass from the sea-bed up into the water column is an analogue of the distribution down from the surface, but with a sharper rate of decrease because of the countering influence of gravity. In deep midwater regions, probably from depths of about 2000-2500m to within 100m of the sea-bed, the influence of the surface is uncoupled from the influence of the sea floor, whereas in shallow neritic seas the systems are closely coupled. The depth down the continental slope at which the de-coupling occurs is unknown but is deeper than the slope samples taken in this study.

The importance of these relationships to the problems of the safety of sea-bed disposal of radioactive waste is centred around how deep-sea systems link with neritic systems in slope regions. At present no evidence has yet come to light of any biological processes in midwater which can transport significant quantities of isotopes from the sea floor up through the water column to the surface, either in terms of dose to Man or of critical pathways (Angel, in press; Needler, in press). This has been supported by the admittedly simplistic, but purposely conservative model developed by Robinson and Mullin (1981) which led to

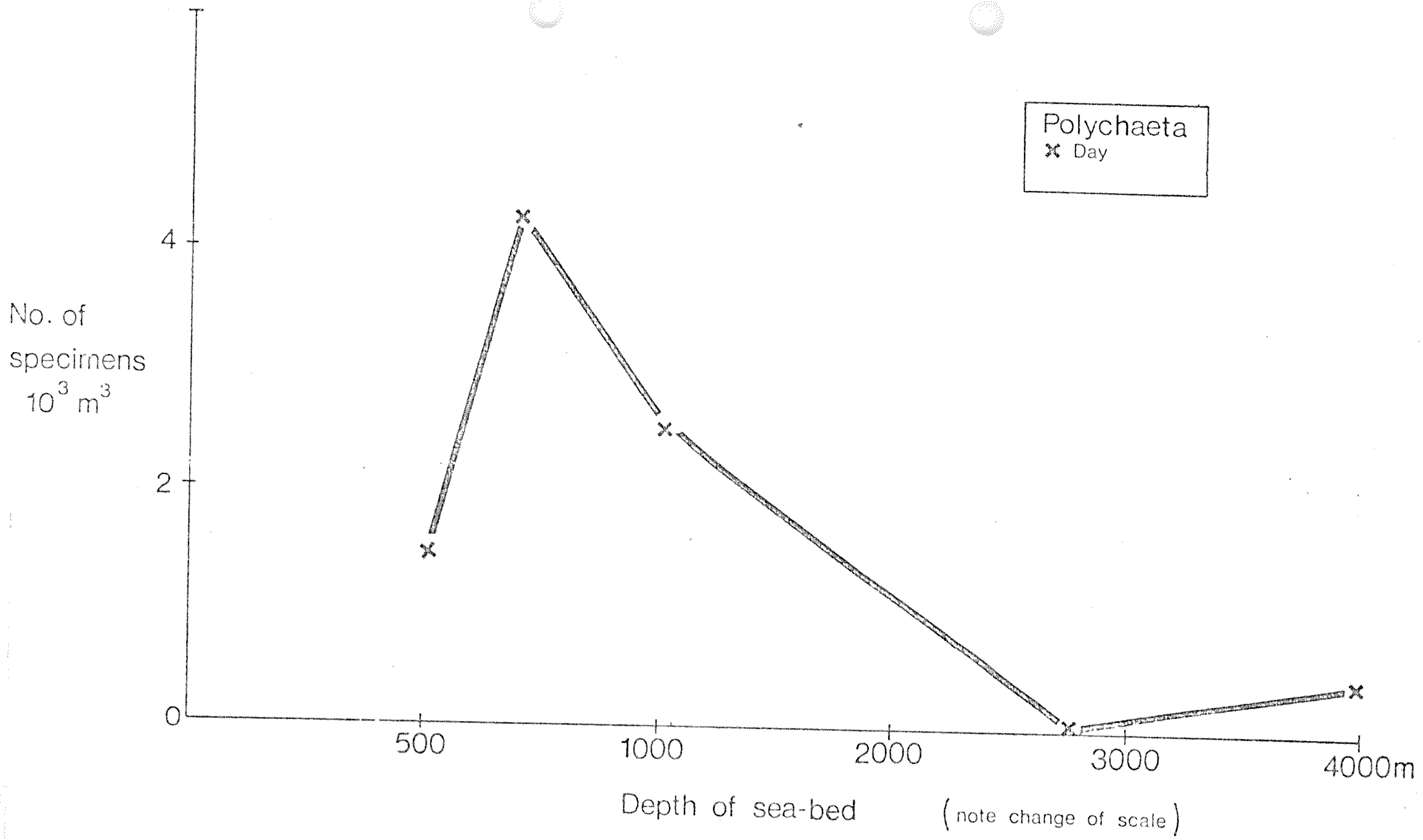

Fig. 61. Profiles of numerical abundance (Nos./1000m^3) of Polychaeta in RMT 8 samples taken near-bottom over the slope, plotted against depth of the sea-bed.

the conclusion that physical processes were likely to be around seven orders of magnitude more important in determining the back flux of waste isotope than biological processes.

The data described here demonstrate the increase in standing crop of both plankton and micronekton associated with close proximity to the sea-bed in slope regions. The amount of increase was much more dramatic in some taxa than in others, for example in the plankton the polychaetes showed a much greater response than the ostracods. However, it was the response of a few dominant groups such as the copepods and decapod crustaceans which determined the pattern of the total community response. These dominant organisms are important constituents of the diets of certain commercial fishes and so their presence could attract these fishes down into deeper water. The only other group for which detailed information is presently available, the mysids, showed a limited response to the proximity to the sea floor and are relatively unimportant in fish diets (Mauchline, 1982). Initial data for some of the decapod species suggest that some of the shallow mesopelagic species appreciably extend their vertical ranges to much greater depths down the slope, than in open water. Moreover, some of these species are well-known as diel vertical migrants in open water.

There was no evidence found in these samples of their undertaking such migrations up from the lower part of their extended vertical ranges of the slope. However, the sampling was not designed to investigate such problems, moreover, if such migrations were asynchronous they would be indetectable by present sampling techniques (Pearre, 1979). Any diel migrations which do occur could provide an important mechanism directly coupling the deep-sea ecosystems with those on the shelf or shallow oceanic water which are either exploited (e.g. for mackerel) or have potential for exploitation (e.g. for blue whiting). Exploratory fishing has already shown that there are stocks of fishes occurring quite well down the slope to depths of 800m or more which may prove commercially exploitable in the future (Bridger, 1978).

The material collected at somewhat shallower depths on the slope during the Challenger cruise provides evidence for another mechanism that could be important. The catches of large numbers of the medusa Aglantha digitale which is known to breed in the upper 100m during the summer months (Williams and Conway, 1981) remind us of the importance and extent of seasonal migrations at high latitudes (i.e. > 40°N). Many planktonic organisms overwinter in a state of diapause in deep water and migrate up into shallow water in the spring. In open water such migrations are vertical but on the slope where the organisms may maintain contact with the sea floor the migrations may be up slope, such migrations are well-known in crayfish off Florida (Herrnkind and Kanciruk, 1978) and evidence based on the size distribution of breeding cycles of benthopelagic fishes (Merrett personal communication) implies extensive cross-slope migrations are a notable feature in the life-history of many of these fishes. The abundance of larval Thysanopoda high up on the slope was another example of probable seasonal or ontogenetic migration.

The timing of these seasonal migrations is subject to some year-to-year variation. For example, in the case of Aglantha digitale the main peak of abundance in the surface 100m occurred in June between 1952 and 1963. In 1973 (Williams and Conway 1981) large mature specimens appeared in the surface 100m in May migrating up from depths of >500m, presumably to breed because at the same time abundant small larval forms suddenly appeared in the surface layers. The larvae continued to build up in both abundance and size through June and into July. In mid-July the vertical range was extended down below 100m to at least 500m (the lower limit of sampling); this was probably the downward migration to the overwintering depths. Angel et al., (1982) observed large numbers at depths of 1000m at 42°N 17°W which were possibly a population about to make the migration up into the surface layers. Williams and Conway (1981) found densities of mature medusae of $1/10m^3$ amassing at the surface. The maximum dry weight value of the mature forms was 4mg (= 2% wet weight), so the upward flux of Aglantha biomass only totals about $40mg/m^2$ of sea surface. The reverse flux down out of the surface 100m in late summer is probably larger by a factor of at least two. Although the flux for this particular organism is relatively trivial, the integrated community movement may be more significant. Either of these migrations down into deep water or up towards the surface may be important mechanisms for transporting isotopes into or out of the surface water. These seasonal variations in the direction of the flux could be a significant factor in the management of waste disposal, although such short time scale events may prove irrelevant.

Continental slopes are probably important regions for sedimentation of organic material (Walsh, 1983) and this is borne out by the accumulations of phytoplankton detritus that have been observed in the Porcupine Seabight (Billett et al., 1983) which must have rapidly sedimented out of the water column soon after the onset of the Spring Bloom.

During the cruise by RRS Challenger this spring (1983) an attempt was made to try to follow the dynamics of this phytodetritus formation. However, the high frequency of storms kept the surface 500m of the water column well mixed throughout the duration of the cruise and so inhibited the development of the Spring Bloom. Layers of turbid water were identified with a transmissometer at depths of at least 500m which were shown to have a relatively high chlorophyll fluorescence. It is thought that this turbidity was caused by surface water containing phytoplankton being mixed down isopycnals (Fasham, personal communication). Fine mesh net samples of phytoplankton and also core samples of the underlying sediments were collected for thorium analyses by Dr. R. Lampitt (IOS) in collaboration with Dr. C. Lambert (CNEXO, Paris). Initial results (Lambert, personal communication) indicate that thorium is bound onto the phytoplankton and other organic particulates in the surface waters. During the course of the cruise (one month) concentrations in the superficial bottom sediments of a thorium isotope with a half life of only 16 days increased by an order of magnitude. So despite the delayed onset of the Spring Bloom substantial and rapid sedimentation of organic material had already begun to occur, carrying down isotopes scavenged out of the water column. Thus active sedimentation processes in slope regions (e.g. Walsh 1983) may be accelerating the deposition of isotopes on to the bottom which are scavenged and bound onto the surface of phytoplankton detritus. The fate of the organic material in the phytodetritus is still unknown, but as only a relatively small proportion gets permanently incorporated into the sediments (Muller and Suess, 1979) the majority probably gets utilised by benthic respiration (e.g. Hinga <u>et al.</u>, 1979) but some could be recycled back into the surface layers. Consequently the high level of biological activity in the near-bottom zone on the slope and its possible links with exploited stocks needs more thorough investigation.

The seasonality of the organic input also needs to be investigated as this is almost certainly the mechanism which triggers the synchronised reproductive activity of many of the echinoderms at these depths (Tyler et al., 1982). It may also be an important environmental factor in stimulating the migrations of fishes. Similarly the trend for biomass to increase in close proximity to the sea-bed in most micronektonic groups at the majority of the slope stations (see Table 6) may be a seasonal phenomenon. Two types of seasonal migration may occur, one a feeding migration to exploit the abundance of organic material sedimenting onto the sea-bed during the season of high surface productivity, the other a life-cycle

Table 6. A summary of relative changes in biomass in hauls at the slope stations (Cruise 105) with increasing proximity to the sea floor.

	Net	Stations			
	(RMTM)	10111	10108	10109	10110
Total biomass	8	+	+	+	-
Fish	8	+	+	+	+
Medusae	8	+	+	-	-
Chaetognatha	8	+	+	*	+
Chaetognatha	1	+	*	+	+
Siphonophora	8	+	+	+	+
Mysidacea	8	+	*	+	-
Decapoda	8	*	+	+	+
Polychaeta	8	-	+	+	-
Polychaeta	1	+	+	+	+
Copepoda	1	+	+	+	+
Amphipoda	1	+	+	+	+

\+ increase   - decrease   * variable

migration during which the deep water is 'used' as a sanctuary from the high predation pressure of shallow depths, by resting or diapausing organisms, particularly during the seasons of low surface production. The latter migration is likely to be less significant because diapausing organisms do not feed, so they would only take up isotopes from solution and would not be exposed to particulate-bound isotopes.

The examination of the data for individual species gives further insight into the processes that may be taking place. In deep water (i.e. depths of >4000m) there is a considerable novel element in the near-bottom plankton community; for example, the hauls taken very close to the sea-bed at a depth of 4000m at 20°N 21°W in 1978 by RRS Discovery contained a totally novel fauna including at least 25 new species of planktonic ostracod. In contrast the ostracod material from the Porcupine Seabight contained only a single novel species C. hystrix (Angel and Ellis, 1981). At present there is no material available to assess whether there are direct faunistic links between the abyssal and the slope near sea-bed communities. What has been established here is that there are faunistic links between midwater communities inhabiting the water columns over potential dump-sites i.e. KTF and GME, many of the species sampled over the slope in the Porcupine Seabight region are well-known as species inhabiting much of the temperate and subtropical Northeast Atlantic (e.g. IOS Biological Database). Furthermore, there is evidence of quite marked changes in vertical distribution ranges over the slope in a number of taxonomic groups for which detailed analyses of their specific compositions have been carried out (i.e. ostracods and decapods). In the majority of examples there is an extension of the vertical range of normally mesopelagic species down into bathypelagic depths, but in one case (Conchoecia pusilla) it is the emergence of a shallow bathypelagic species up into mesopelagic depths.

In the vicinity of continental slopes the links between the surface community and the deeper living community are probably more dynamic than over deep water. At present there are insufficient data to establish whether these links extend right to the base of the slope, and so may provide faster transport pathways for isotope movement than occur in midwater between abyssal communities and those in more direct contact with Man via his exploitation of living resources. Similarly vertical mixing by physical processes are more dynamic in slope regions than in open ocean conditions, although there are few available quantitative data. So it is still an open question as to just how important the more dynamic interactions are in slope regions as compared with the physical mixing relative to the movement of isotopes within the oceanic ecosystem.

4. CONCLUSIONS

1. There is a marked increase in planktonic and micronektonic biomass within 100m of the sea-bed in the slope region.

2. This increase is probably the result of the greater availability of food created by the sedimentation of surface production accumulating on the sea-bed.

3. On the slope the biomass consisted almost totally of species familiar as mesopelagic and bathypelagic species in deep water. There was no evidence, down to the maximum sampling depth of about 1600m, of the appearance of the highly novel fauna encountered at abyssal depths of 4000m off N W Africa.

4. Several species familiar as mesopelagic species over deep water extended their vertical ranges down the slope, but only one bathypelagic species extended its vertical range shallower up the slope.

5. Large concentrations of the medusa *Aglantha digitale* were encountered and these were probably a population which had undertaken a seasonal migration down from the surface 100m the previous summer and would have probably been returning to the surface to breed later on. Seasonal migrations may either result from diapausing organisms seek refuge at depth during the non-productive season, or the result of the increased food availability on the sea-bed associated with the substantial quantities of detritus sinking out during bloom conditions at the surface.

6. Slope regions are likely to be sites of a dynamic interface between the deep-living benthic and benthopelagic deep water communities and the shallower living shelf communities. Thus if substantial quantities of isotopes do get transported onto the slope biological systems could play a significant part in moving them up slope onto the shelf. However, at present there is no way of assessing the importance of such biological transport relative to transportation by physical processes.

CRUISE 105
29/ 8/79-23/10/79

STN.	DATE	START POSITION LAT	START POSITION LONG	END POSITION LAT	END POSITION LONG	GEAR	SAMPLER DEPTH(M)	DURATION GMT	FLOW/LOG DIST.(KM)	WATER DEPTH(M)
10105/ 1	31/ 8							DUSK		2841
		54 37.7N	12 22.1W	54 34.7N	12 28.8W	RMT1M/1	900-1100	1953-2153	6.61 FLOW	
		54 37.7N	12 22.1W	54 34.7N	12 28.8W	RMT8M/1	900-1100	1953-2153	6.61 FLOW	
10105/ 2	31/ 8							NIGHT		2864
		54 34.7N	12 28.8W	54 31.6N	12 35.7W	RMT1M/2	1090-1290	2153-2353	6.81 FLOW	
		54 34.7N	12 28.8W	54 31.6N	12 35.7W	RMT8M/2	1090-1290	2153-2353	6.81 FLOW	
10105/ 3	31/ 8							NIGHT		2875
		54 31.6N	12 35.7W	54 28.3N	12 42.7W	RMT1M/3	1290-1500	2353- 153	7.39 FLOW	
		54 31.6N	12 35.7W	54 28.3N	12 42.7W	RMT8M/3	1290-1500	2353- 153	7.39 FLOW	
10105/ 5	1/ 9							DAY		2866
		54 35.5N	12 25.1W	54 33.5N	12 23.5W	RMT1M/1	600- 700	1051-1151	3.51 FLOW	
		54 35.5N	12 25.1W	54 33.5N	12 23.5W	RMT8M/1	600- 700	1051-1151	3.51 FLOW	
10105/ 6	1/ 9							DAY		
		54 33.5N	12 23.5W	54 31.6N	12 21.7W	RMT1M/2	700- 810	1151-1255	3.82 FLOW	
		54 33.5N	12 23.5W	54 31.6N	12 21.7W	RMT8M/2	700- 810	1151-1255	3.82 FLOW	
10105/ 7	1/ 9							DAY		
		54 31.6N	12 21.7W	54 29.6N	12 20.0W	RMT1M/3	800- 900	1255-1355	3.64 FLOW	
		54 31.6N	12 21.7W	54 29.6N	12 20.0W	RMT8M/3	800- 900	1255-1355	3.64 FLOW	
10105/ 8	1/ 9							DAY		2883
		54 28.1N	12 19.2W	54 26.0N	12 18.2W	RMT1M/1	300- 410	1529-1629	4.05 FLOW	
		54 28.1N	12 19.2W	54 26.0N	12 18.2W	RMT8M/1	300- 410	1529-1629	4.05 FLOW	
10105/ 9	1/ 9							DAY		2883
		54 26.0N	12 18.2W	54 24.2N	12 16.7W	RMT1M/2	405- 500	1629-1729	3.78 FLOW	
		54 26.0N	12 18.2W	54 24.2N	12 16.7W	RMT8M/2	405- 500	1629-1729	3.78 FLOW	
10105/10	1/ 9							DAY		2884
		54 24.2N	12 16.7W	54 22.4N	12 15.1W	RMT1M/3	500- 600	1729-1829	3.82 FLOW	
		54 24.2N	12 16.7W	54 22.4N	12 15.1W	RMT8M/3	500- 600	1729-1829	3.82 FLOW	
10105/11	1/ 9							NIGHT		
		54 35.0N	12 27.8W	54 35.3N	12 32.9W	RMT1M/1	600- 700	2302- 2	3.73 FLOW	
		54 35.0N	12 27.8W	54 35.3N	12 32.9W	RMT8M/1	600- 700	2302- 2	3.73 FLOW	
10105/12	2/ 9							NIGHT		
		54 35.3N	12 32.8W	54 36.4N	12 40.7W	RMT1M/2	700- 810	2- 141	6.71 FLOW	
		54 35.3N	12 32.8W	54 36.4N	12 40.7W	RMT8M/2	700- 810	2- 141	6.71 FLOW	
10105/13	2/ 9							NIGHT		
		54 36.4N	12 40.7W	54 37.6N	12 45.0W	RMT1M/3	770- 900	141- 241	3.46 FLOW	
		54 36.4N	12 40.7W	54 37.6N	12 45.0W	RMT8M/3	770- 900	141- 241	3.46 FLOW	

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10105/14    2/ 9                                                       DAY
                 54 38.9N  12 17.8W  54 37.5N  12 21.5W  RMT1M/1       10- 100   716- 816   3.73 FLOW   2913
                 54 38.9N  12 17.8W  54 37.5N  12 21.5W  RMT8M/1       10- 100   716- 816   3.73 FLOW

10105/15    2/ 9                                                       DAY
                 54 37.6N  12 21.4W  54 36.6N  12 26.3W  RMT1M/2      100- 195   816- 916   3.87 FLOW   2927
                 54 37.6N  12 21.4W  54 36.6N  12 26.3W  RMT8M/2      100- 195   816- 916   3.87 FLOW

10105/16    2/ 9                                                       DAY
                 54 36.6N  12 26.1W  54 36.0N  12 31.3W  RMT1M/3      195- 300   916-1016   4.00 FLOW   2932
                 54 36.6N  12 26.1W  54 36.0N  12 31.3W  RMT8M/3      195- 300   916-1016   4.00 FLOW

10105/17    2/ 9                                                       DAY
                 54 38.9N  12 31.2W  54 39.7N  12 39.8W  RMT1M/1     1500-1700  1329-1529   8.14 FLOW   2929
                 54 38.9N  12 31.2W  54 39.7N  12 39.8W  RMT8M/1     1500-1700  1329-1529   8.14 FLOW

10105/18    2/ 9                                                       DAY
                 54 39.7N  12 39.8W  54 41.2N  12 47.7W  RMT1M/2     1700-1900  1529-1729   8.54 FLOW
                 54 39.7N  12 39.8W  54 41.2N  12 47.7W  RMT8M/2     1700-1900  1529-1729   8.54 FLOW

10105/19    2/ 9                                                       NIGHT
                 54 43.5N  12 55.2W  54 44.9N  12 57.6W  RMT1M/1      500- 600  2056-2156   3.28 FLOW   2918
                 54 43.5N  12 55.2W  54 44.9N  12 57.6W  RMT8M/1      500- 600  2056-2156   3.28 FLOW

10105/20    2/ 9                                                       NIGHT
                 54 44.9N  12 57.5W  54 46.3N  13  0.2W  RMT1M/2      400- 500  2156-2256   3.55 FLOW   2920
                 54 44.9N  12 57.5W  54 46.3N  13  0.2W  RMT8M/2      400- 500  2156-2256   3.55 FLOW

10105/21    2/ 9                                                       NIGHT
                 54 46.2N  13  0.1W  54 47.6N  13  3.0W  RMT1M/3      300- 405  2256-2356   3.64 FLOW   2915
                 54 46.2N  13  0.1W  54 47.6N  13  3.0W  RMT8M/3      300- 405  2256-2356   3.64 FLOW

10105/22    3/ 9                                                       NIGHT
                 54 49.6N  13  6.6W  54 51.3N  13  9.5W  RMT1M/1      200- 300   119- 219   4.09 FLOW
                 54 49.6N  13  6.6W  54 51.3N  13  9.5W  RMT8M/1      200- 300   119- 219   4.09 FLOW

10105/23    3/ 9                                                       NIGHT
                 54 51.3N  13  9.5W  54 52.8N  13 12.7W  RMT1M/2      100- 200   219- 319   4.27 FLOW
                 54 51.3N  13  9.5W  54 52.8N  13 12.7W  RMT8M/2      100- 200   219- 319   4.27 FLOW

10105/24    3/ 9                                                       NIGHT
                 54 52.8N  13 12.7W  54 54.4N  13 15.8W  RMT1M/3       10- 100   319- 419   4.18 FLOW   2890
                 54 52.8N  13 12.7W  54 54.4N  13 15.8W  RMT8M/3       10- 100   319- 419   4.18 FLOW

10108/ 3    6/ 9                                                       NIGHT
                 49 16.5N  12 47.7W  49 13.2N  12 51.1W  RMT1M/1       10-1100   319- 456   5.14 FLOW   1325
                 49 16.5N  12 47.7W  49 13.2N  12 51.1W  RMT8M/1       10-1100   319- 456   5.14 FLOW
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10108/ 4    6/ 9                                                                        DAWN                    1432
                49 13.3N  12 51.1W  49 11.1N  12 52.4W  RMT1M/2        1100-1230   456- 556    4.45 FLOW
                49 13.3N  12 51.1W  49 11.1N  12 52.4W  RMT8M/2        1100-1230   456- 556    4.45 FLOW

10108/ 5    6/ 9                                                                        DAWN                    1584
                49 11.2N  12 52.3W  49  9.0N  12 55.1W  RMT1M/3        1230-1300   556- 656    4.45 FLOW           ESTIMATED TO WITHIN 125M OF
                49 11.2N  12 52.3W  49  9.0N  12 55.1W  RMT8M/3        1230-1300   556- 656    4.45 FLOW           BOTTOM

10108/ 6    6/ 9                                                                        DAY                     1415
                49 27.8N  12 47.8W  49 25.4N  12 49.1W  RMT1M/1        1210-1350  1147-1247    3.51 FLOW           ESTIMATED TO WITHIN 90M OF
                49 27.8N  12 47.8W  49 25.4N  12 49.1W  RMT8M/1        1210-1350  1147-1247    3.51 FLOW           BOTTOM

10108/ 7    6/ 9                                                                        DAY                     1414
                49 25.4N  12 49.1W  49 23.6N  12 49.6W  RMT1M/2        1350-1410  1247-1347    3.73 FLOW           ESTIMATED 90-30M OFF BOTTOM
                49 25.4N  12 49.1W  49 23.6N  12 49.6W  RMT8M/2        1350-1410  1247-1347    3.73 FLOW

10108/ 8    6/ 9                                                                        DAY                     1411
                49 23.6N  12 49.6W  49 22.6N  12 49.9W  RMT1M/3        1410-1425  1347-1420    1.39 FLOW           ESTIMATED 30-15M OFF BOTTOM
                49 23.6N  12 49.6W  49 22.6N  12 49.9W  RMT8M/3        1410-1425  1347-1420    1.39 FLOW

10109/ 1    6/ 9                                                                        DUSK                    1196
                49 19.9N  12 24.7W  49 18.6N  12 27.5W  RMT1M/1        1000-1100  1814-1914    3.28 FLOW           ESTIMATED TO WITHIN 60M OF
                49 19.9N  12 24.7W  49 18.6N  12 27.5W  RMT8M/1        1000-1100  1814-1914    3.28 FLOW           BOTTOM

10109/ 2    6/ 9                                                                        DUSK                    1180
                49 18.6N  12 27.4W  49 17.4N  12 30.4W  RMT1M/2        1100-1155  1914-2014    3.15 FLOW           ESTIMATED 25-60M OFF BOTTOM
                49 18.6N  12 27.4W  49 17.4N  12 30.4W  RMT8M/2        1100-1155  1914-2014    3.15 FLOW

10109/ 3    6/ 9                                                                        NIGHT                   1175
                49 17.4N  12 30.3W  49 16.2N  12 33.2W  RMT1M/3        1140-1155  2014-2114    5.75 FLOW           ESTIMATED 25-15M OFF BOTTOM
                49 17.4N  12 30.3W  49 16.2N  12 33.2W  RMT8M/3        1140-1155  2014-2114    5.75 FLOW

10109/ 4    6/ 9                                                                        NIGHT                   1192
                49 14.7N  12 37.2W  49 13.6N  12 41.6W  RMT1M/1          10- 900  2237-2357    4.09 FLOW
                49 14.7N  12 37.2W  49 13.6N  12 41.6W  RMT8M/1          10- 900  2237-2357    4.09 FLOW

10109/ 5    6/ 9                                                                        NIGHT                   1227
                49 13.6N  12 41.6W  49 13.1N  12 45.0W  RMT1M/2         780- 940  2357-  57    4.09 FLOW           ESTIMATED 200-310M OFF BOTTOM
                49 13.6N  12 41.6W  49 13.1N  12 45.0W  RMT8M/2         780- 940  2357-  57    4.09 FLOW

10109/ 6    7/ 9                                                                        NIGHT                   1276
                49 13.1N  12 45.0W  49 12.6N  12 48.5W  RMT1M/3         910-1150    57- 157    4.23 FLOW           NET 3 DID NOT FISH
                49 13.1N  12 45.0W  49 12.6N  12 48.5W  RMT8M/3         910-1150    57- 157    4.23 FLOW

10110/ 3    7/ 9                                                                        NIGHT                    905
                49 16.8N  11 45.4W  49 16.5N  11 48.3W  RMT1M/1          10- 810  2029-2124    2.65 FLOW           ESTIMATED TO WITHIN 120M OF
                49 16.8N  11 45.4W  49 16.5N  11 48.3W  RMT8M/1          10- 810  2029-2124    2.65 FLOW           BOTTOM
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10110/ 4    7/ 9                                                                NIGHT              950
               49 16.5N  11 48.2W  49 17.0N  11 50.9W  RMT1M/2       800- 950   2124-2224   2.79 FLOW        ESTIMATED 120-35M OFF
               49 16.5N  11 48.2W  49 17.0N  11 50.9W  RMT8M/2       800- 950   2124-2224   2.79 FLOW        BOTTOM

10110/ 5    7/ 9                                                                NIGHT             1005
               49 17.0N  11 50.8W  49 17.4N  11 53.2W  RMT1M/3       935-1000   2224-2324   2.38 FLOW        ESTIMATED 40-15M OFF BOTTOM
               49 17.0N  11 50.8W  49 17.4N  11 53.2W  RMT8M/3       935-1000   2224-2324   2.38 FLOW

10111/ 1    8/ 9                                                                DAY               1760
               49 36.8N  13  3.1W  49 37.8N  13  9.1W  RMT1M/1        10-1500    634- 809   4.24 FLOW
               49 36.8N  13  3.1W  49 37.8N  13  9.1W  RMT8M/1        10-1500    634- 809   4.24 FLOW

10111/ 2    8/ 9                                                                DAY               1755
               49 37.8N  13  9.1W  49 38.2N  13 12.6W  RMT1M/2      1500-1610    809- 910   3.73 FLOW        ESTIMATED 200-100M OFF
               49 37.8N  13  9.1W  49 38.2N  13 12.6W  RMT8M/2      1500-1610    809- 910   3.73 FLOW        BOTTOM

10111/ 3    8/ 9                                                                DAY               1735
               49 38.2N  13 12.5W  49 38.2N  13 14.4W  RMT1M/3      1610-1670    910- 943   2.04 FLOW        ESTIMATED 100-40M OFF BOTTOM
               49 38.2N  13 12.5W  49 38.2N  13 14.4W  RMT8M/3      1610-1670    910- 943   2.04 FLOW

10111/ 4    8/ 9                                                                DAY               1660
               49 34.5N  13  7.9W  49 34.7N  13 12.5W  RMT1M/1      1480-1570   1405-1505   3.96 FLOW        ESTIMATED 40-90M OFF BOTTOM
               49 34.5N  13  7.9W  49 34.7N  13 12.5W  RMT8M/1      1480-1570   1405-1505   3.96 FLOW

10111/ 5    8/ 9                                                                DAY               1647
               49 34.7N  13 12.5W  49 34.9N  13 16.7W  RMT1M/2      1555-1570   1505-1605   4.77 FLOW        ESTIMATED 25-30M OFF BOTTOM
               49 34.7N  13 12.5W  49 34.9N  13 16.7W  RMT8M/2      1555-1570   1505-1605   4.77 FLOW

10111/ 6    8/ 9                                                                DAY               1685
               49 34.9N  13 16.7W  49 35.2N  13 21.0W  RMT1M/3      1560-1650   1605-1705   4.41 FLOW        ESTIMATED 10-25M OFF BOTTOM
               49 34.9N  13 16.7W  49 35.2N  13 21.0W  RMT8M/3      1560-1650   1605-1705   4.41 FLOW

10115/ 2   11/ 9                                                                DAY               4030
               49 44.6N  13 59.2W  49 45.8N  14  2.0W  RMT1M/1       600- 700   1013-1113   3.15 FLOW
               49 44.6N  13 59.2W  49 45.8N  14  2.0W  RMT8M/1       600- 700   1013-1113   3.15 FLOW

10115/ 3   11/ 9                                                                DAY               4022
               49 45.8N  14  2.0W  49 47.0N  14  5.0W  RMT1M/2       700- 800   1113-1213   3.37 FLOW
               49 45.8N  14  2.0W  49 47.0N  14  5.0W  RMT8M/2       700- 800   1113-1213   3.37 FLOW

10115/ 4   11/ 9                                                                DAY
               49 47.0N  14  5.0W  49 48.1N  14  8.0W  RMT1M/3       800- 900   1213-1313   3.28 FLOW
               49 47.0N  14  5.0W  49 48.1N  14  8.0W  RMT8M/3       800- 900   1213-1313   3.28 FLOW

10115/ 5   11/ 9                                                                DAY               4052
               49 47.8N  14  9.1W  49 45.6N  14  7.4W  RMT1M/1       300- 400   1420-1520   3.51 FLOW
               49 47.8N  14  9.1W  49 45.6N  14  7.4W  RMT8M/1       300- 400   1420-1520   3.51 FLOW
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10115/ 6   11/ 9                                                                  DAY                     4075
               49 45.7N  14  7.4W  49 43.7N  14  5.9W  RMT1M/2         400- 500  1520-1620   3.46 FLOW
               49 45.7N  14  7.4W  49 43.7N  14  5.9W  RMT8M/2         400- 500  1520-1620   3.46 FLOW

10115/ 7   11/ 9                                                                  DAY                     4095
               49 43.8N  14  5.9W  49 41.9N  14  4.2W  RMT1M/3         500- 600  1620-1720   3.33 FLOW
               49 43.8N  14  5.9W  49 41.9N  14  4.2W  RMT8M/3         500- 600  1620-1720   3.33 FLOW

10115/ 9   11/ 9                                                                  NIGHT                   4135
               49 42.0N  14  3.3W  49 44.2N  14  4.9W  RMT1M/1         600- 700  2102-2202   3.46 FLOW
               49 42.0N  14  3.3W  49 44.2N  14  4.9W  RMT8M/1         600- 700  2102-2202   3.46 FLOW

10115/10   11/ 9                                                                  NIGHT
               49 44.2N  14  4.9W  49 46.3N  14  6.5W  RMT1M/2         700- 800  2202-2302   3.64 FLOW
               49 44.2N  14  4.9W  49 46.3N  14  6.5W  RMT8M/2         700- 800  2202-2302   3.64 FLOW

10115/11   11/ 9                                                                  NIGHT
               49 46.3N  14  6.5W  49 48.4N  14  8.0W  RMT1M/3         800- 900  2302-   2   3.64 FLOW
               49 46.3N  14  6.5W  49 48.4N  14  8.0W  RMT8M/3         800- 900  2302-   2   3.64 FLOW

10115/12   12/ 9                                                                  NIGHT                   3995
               49 51.9N  14 10.5W  49 53.9N  14 11.5W  RMT1M/1         295- 400   148- 248   3.69 FLOW
               49 51.9N  14 10.5W  49 53.9N  14 11.5W  RMT8M/1         295- 400   148- 248   3.69 FLOW

10115/13   12/ 9                                                                  NIGHT                   3985
               49 53.8N  14 11.5W  49 55.9N  14 12.3W  RMT1M/2         400- 500   248- 348   3.51 FLOW
               49 53.8N  14 11.5W  49 55.9N  14 12.3W  RMT8M/2         400- 500   248- 348   3.51 FLOW

10115/14   12/ 9                                                                  NIGHT                   3930
               49 55.8N  14 12.3W  49 57.8N  14 12.7W  RMT1M/3         500- 600   348- 448   3.28 FLOW
               49 55.8N  14 12.3W  49 57.8N  14 12.7W  RMT8M/3         500- 600   348- 448   3.28 FLOW

10115/15   12/ 9                                                                  DAY
               49 45.4N  13 58.9W  49 43.4N  13 57.6W  RMT1M/1          10- 100   804- 904   3.64 FLOW
               49 45.4N  13 58.9W  49 43.4N  13 57.6W  RMT8M/1          10- 100   804- 904   3.64 FLOW

10115/16   12/ 9                                                                  DAY
               49 43.5N  13 57.6W  49 41.6N  13 56.5W  RMT1M/2         100- 200   904-1004   3.73 FLOW
               49 43.5N  13 57.6W  49 41.6N  13 56.5W  RMT8M/2         100- 200   904-1004   3.73 FLOW

10115/17   12/ 9                                                                  DAY                     4020
               49 41.7N  13 56.5W  49 39.8N  13 55.6W  RMT1M/3         200- 300  1004-1104   3.64 FLOW
               49 41.7N  13 56.5W  49 39.8N  13 55.6W  RMT8M/3         200- 300  1004-1104   3.64 FLOW

10115/18   12/ 9                                                                  DAY
               49 38.5N  13 57.8W  49 36.6N  14  4.0W  RMT1M/1         910-1100  1212-1414   6.56 FLOW
               49 38.5N  13 57.8W  49 36.6N  14  4.0W  RMT8M/1         910-1100  1212-1414   6.56 FLOW
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10115/19   12/ 9                                                          DAY
                  49 36.7N  14  3.9W  49 38.1N  14  9.5W  RMT1M/2   1100-1300  1414-1615   7.82 FLOW
                  49 36.7N  14  3.9W  49 38.1N  14  9.5W  RMT8M/2   1100-1300  1414-1615   7.82 FLOW

10115/20   12/ 9                                                          DAY
                  49 38.1N  14  9.5W  49 42.4N  14 11.3W  RMT1M/3   1300-1505  1615-1816   7.19 FLOW
                  49 38.1N  14  9.5W  49 42.4N  14 11.3W  RMT8M/3   1300-1505  1615-1816   7.19 FLOW

10115/21   12/ 9                                                          NIGHT
                  49 46.1N  14  9.9W  49 47.8N  14  8.3W  RMT1M/1     10- 100  2053-2153   3.96 FLOW
                  49 46.1N  14  9.9W  49 47.8N  14  8.3W  RMT8M/1     10- 100  2053-2153   3.96 FLOW

10115/22   12/ 9                                                          NIGHT
                  49 47.8N  14  8.3W  49 49.5N  14  7.0W  RMT1M/2    100- 200  2153-2253   3.87 FLOW
                  49 47.8N  14  8.3W  49 49.5N  14  7.0W  RMT8M/2    100- 200  2153-2253   3.87 FLOW

10115/23   12/ 9                                                          NIGHT
                  49 49.5N  14  7.0W  49 51.2N  14  5.5W  RMT1M/3    195- 300  2253-2353   2.65 FLOW
                  49 49.5N  14  7.0W  49 51.2N  14  5.5W  RMT8M/3    195- 300  2253-2353   2.65 FLOW
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CRUISE 506
29/ 6/79-11/ 7/79

STN.	DATE	START LAT	POSITION LONG	END LAT	POSITION LONG	GEAR	SAMPLER DEPTH(M)	DURATION GMT	FLOW/LOG DIST.(KM)	WATER DEPTH(M)
50603/ 2	3/ 7							DAY		3980
		49 53.9N	14 8.9W	49 55.7N	14 11.5W	RMT1	3720-3940	746- 852	4.63 FLOW	
		49 53.9N	14 8.9W	49 55.7N	14 11.5W	RMT8	3720-3940	746- 852	4.63 FLOW	
50603/ 3	3/ 7							DAY		3925
		49 53.4N	14 4.1W	49 50.8N	13 59.3W	RMT1	3500-3710	1728-1830	4.45 FLOW	
		49 53.4N	14 4.1W	49 50.8N	13 59.3W	RMT8	3500-3710	1728-1830	4.45 FLOW	
50605/ 2	5/ 7							DAY		2735
		50 6.5N	13 12.0W	50 5.9N	13 7.2W	RMT1	2640-2750	907-1030	5.71 FLOW	
		50 6.5N	13 12.0W	50 5.9N	13 7.2W	RMT8	2640-2750	907-1030	5.71 FLOW	
50606/ 3	6/ 7							DAY		1195
		50 39.9N	13 59.3W	50 39.9N	14 5.1W	RMT1	1090-1160	1026-1226	6.70 FLOW	
		50 39.9N	13 59.3W	50 39.9N	14 5.1W	RMT8	1090-1160	1026-1226	6.70 FLOW	
50606/ 4	6/ 7							DAY		1100
		50 42.1N	14 4.3W	50 42.7N	13 59.1W	RMT1	400- 500	1354-1524	6.61 FLOW	
		50 42.1N	14 4.3W	50 42.7N	13 59.1W	RMT8	400- 500	1354-1524	6.61 FLOW	
50607/ 3	7/ 7							DAY		686
		51 3.2N	14 14.2W	51 4.9N	14 19.9W	RMT1	655- 680	1005-1205	6.00 FLOW	
		51 3.2N	14 14.2W	51 4.9N	14 19.9W	RMT8	655- 680	1005-1205	6.00 FLOW	
50607/ 4	7/ 7							DAY		690
		51 4.6N	14 21.7W	51 5.2N	14 29.3W	RMT1	0- 650	1301-1349	3.19 FLOW	
		51 4.6N	14 21.7W	51 5.2N	14 29.3W	RMT8	0- 650	1301-1349	3.19 FLOW	
50608/ 1	7/ 7							DAY		512
		51 19.5N	14 20.7W	51 19.5N	14 20.3W	RMT1	460- 495	1748-1818	2.20 FLOW	
		51 19.5N	14 20.7W	51 19.5N	14 20.3W	RMT8	460- 495	1748-1818	2.20 FLOW	
50609/ 2	8/ 7							NIGHT		408
		51 38.7N	14 20.6W	51 38.0N	14 22.4W	RMT1	380- 395	231- 301	1.89 FLOW	
		51 38.7N	14 20.6W	51 38.0N	14 22.4W	RMT8	380- 395	231- 301	1.89 FLOW	

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